FEILDEN'S MAGAZINE.

20th Issue. MARCH, 1901. Vol. 4. No. 3.

Probable Effect upon British Commerce with Pacific and British Carrying Trade of the opening of Inter-Oceanic Communication across the American Continent.

In our December number we dedicated a considerable space to the recent engineering and political history of the rival canal undertakings which are making a bid for the honour of revolutionising the great westerly trade routes of the world. In view of the supreme importance of the questions involved, in the threatened revolution in these trade routes, to the nation which has been for so long and still is the chief ocean carrier of the world's commerce, we feel that it is incumbent upon us to revert to these canal projects thus early in the new century, to point out more particularly the very serious results to be anticipated from their successful completion, upon the supreme life-and-death struggle to which "willy nilly" our manufacturing interests are undoubtedly committed in this opening century. The distribution of the globe's great land areas is such that the cutting of an inter-oceanic canal across an isthmus in only two cases could modify or alter to any sensible extent the great ocean trade routes of the world, viz., the Isthmus of Suez for the trade routes to the east, and the Central American isthmus for the trade routes to the west. The mere publication of tables of figures of steaming distances, showing the saving effected by the opening of one or other of the above supremely important canals, does not by any means ensure a thorough grasp of the practical import of the existence or non-existence of these canals upon the carrying trade of this country. The tables published with our December number gave some of the most striking economies in steaming distances to be effected by the cutting of the Central American canal. Exhaustive tables of competing distances between Liverpool and Marseilles on the European side and New York and New Orleans on the American side, and various leading trade centres in the Pacific *viâ* the Suez and Central American canals and round the Cape of Good Hope and Cape Horn respectively were published by our old contemporary, *Engineering*, in April, 1893, in connection with a series of articles on the Nicaragua Canal. These tables conclusively showed that the effect of the cutting of a first-class ship canal across the American isthmus would inevitably be at least as great on the ocean trade of the world as that of the Suez Canal—but, that relatively, the effect would be far greater on the commerce of the United States than on that of the United Kingdom, and must commensurately affect their respective carrying trade throughout the Pacific. Without recapitulating strings of figures which are, even for experts, more or less of a weariness of the flesh, we would ask our readers to open a map of the world and with a coloured pencil draw a line along the west coast line of

North, Central, and South America, from Alaska to Patagonia, and another coloured line from the South-West Cape of Australia through the North Cape across to where the 136 meridian cuts New Guinea, thence to the easternmost cape of the northern island of the Philippines, then through Amoy and on across China and Siberia to the mouth of the River Lena. The first line will represent very closely the position of the present neutral competing zone for the sea-borne commerce to and from the United States Atlantic ports and to and from Western European ports with the Pacific; the second, the new position of the same neutral zone after the opening of a waterway across the American isthmus. Whereas, under existing conditions of ocean communication the eastern sea-board of the United States, in respect to ocean carriage in the Pacific, is only in a position of equality with the western sea-board of Europe as far as the western sea-board of the Americas are concerned, and is handicapped everywhere else to the extent of the average distances across that ocean, immediately a canal is opened across the American isthmus the tables will be completely turned. European Atlantic commerce in the Pacific will then be only in a position of equality with American Atlantic commerce along the eastern coast line of the Asiatic continent, the Asiatic archipelago, and that of Australasia, while along the west coast of the Americas European sea-borne trade, as compared with American, will be handicapped by the average width of the Pacific Ocean. The only reasonable inference is that the effect of the opening of such a canal upon the trade of the Americas, not only between themselves but also between them and the far East, cannot fail to be wholly unprecedented in magnitude, and that the impulse derived therefrom will at least equal and probably exceed in extent the impulse given to European trade by the opening of the Suez Canal. While the relative intrinsic importance of the easterly and westerly ocean trade routes of the world to and from the far East and the Australias will remain unaltered, as far as the trade centres of the Atlantic seaboard of Europe are concerned, and continue to be enormously in favour of the Suez Canal route, their relative importance will be entirely reversed as far as the Atlantic sea-board of America is concerned. This change in intrinsic value must inevitably centre the commercial interests and the carrying trade of the Americas more and more exclusively around the development and control of the competing great westerly trade route to the obviously serious detriment of the older route, in which we are so supremely interested.

Being in the position of chief ocean carriers to the sea-coast populations of the world, as well as late universal provider to most of these and most of the hinterland populations besides, we are obviously concerned in the key to the world's westerly trade route to a degree falling not far short of that which represents our interest in the key to the easterly trade route. In the latter case this is measured by the ownership of the whole of the founders' shares in the company which constructed this, and the usership thereof to the extent of over 76 per cent. of the total tonnage passing through it. What then is and should be our proposed interest in the Central American canal? The policy of this country towards the canal projects, forming the keys to the two improved ocean trade routes, offers many a curious historical parallel and also a notable contrast, this latter due to the relative remoteness of the respective epochs in which the canal projects took their rise. The origins of the Suez Canal are hidden in the mists of Egyptian history, and probably arose in the ambition of some wide-awake Pharaoh better provided with skilled engineering advisers than his predecessors. This Pharaoh evidently grasped the possibility of undoing the mischief wrought by Nature in the gradual destruction and obliteration of the ancient navigable channel between the Red Sea and the Eastern Mediterranean, and made an ineffectual attempt to carry out the idea. The echo of this ambitious idea lay dormant for ages, practically forgotten till the civilisation of buried Egypt was brought to light in consequence of Napoleon the First's scientific expeditions to that country. Eventually, however, it reached

the brain of an ambitious Frenchman, who took up the idea of the forgotten Pharaoh and dug the canal he had planned and essayed in the far-off past. In this case we awoke too late to the practicability of the idea to immediately attempt to control the route of the canal, and had to content ourselves with trying to postpone its realisation by engineering prophecies which did not redound to the credit of our engineers, leaving it to a subsequent generation to repair our want of political forethought by seizing an unexpected opportunity of control offered by the financial embarrassments of the Khedive. The origins of the Central American canal schemes only date back to the middle of the 16th century, and are directly traceable to the order given by Charles V. to discover the secret channel which native Indian tradition stated existed across Central America. The evidence, geological and other, since collected with reference to the region about Lake Nicaragua prove that this lake, at no very remote period, did actually drain into both oceans, *i.e.* that water communication actually existed across the American isthmus at this point and afforded a substantial basis to the Indian reports. It seems, therefore, that in this case also the idea of a canal had its origin in the ambition of a wide-awake ruler to repair the mischief, wrought by Dame Nature to a natural waterway across an isthmus uniting two continents, by human agency and the substitution therefor of an artificial canal. However this may have been, the Spaniards never doubted either the immediate possibility, the practicability, or the importance of a canal across Nicaragua, and, it may be added, neither did we. In proof of this it is only necessary to point out that the 300 years intervening between the middle of the sixteenth and the middle of the nineteenth centuries present an almost continuous series of overt and covert armed attempts on the part of Great Britain and her subjects to seize and control the region through which the Nicaragua Canal will pass. These attempts were only discontinued at the epoch of the Clayton-Bulwer treaty, when it became apparent to our statesmen, through the discovery of gold in California, that new trade centres must inevitably be developed on the Western Continent as rival trade centres to Western Europe, *i.e.* England, the commercial rivalry of which would be only accelerated by the perfecting of the westerly trade route. The onus of building a canal across Nicaragua, which was then universally considered the only practicable route across the isthmus, was deliberately thrown by that treaty into the hands of the United States, and by the exercise of this diplomatic foresight the postponement of its construction has been secured for over 50 years. By the recent Hay-Pauncefote convention we have, however, as deliberately relinquished one of the most important advantages secured to us by that treaty, viz., the joint guarantee of and responsibility for the neutrality of the canal when built, by which device we had skilfully handicapped the control which our cousins expected to exercise over their canal when built, in favour of British sea power. If we have now deliberately consented to the abrogation of these clauses, which, in view of the speedy construction of the Nicaraguan Canal, were undoubtedly the most important of the Clayton-Bulwer treaty, it is because the existence of a canal across the isthmus has now become of supreme importance to the trade development of our Canadian dominion. We have consented because the removal of what the United States considered serious disabilities in the way of the building of the canal by the American government, seemed to be the only practical and expeditious way of securing the desired inter-oceanic communication. It is to be hoped that the old "mother country's" self-sacrifice in this matter for the sake of her eldest federated daughter will be accounted to her for righteousness when the serious drawbacks to her commerce and to her carrying trade and sea power, involved in the perfecting of the great trade route, become hereafter fully apparent. In the light of the work recently carried out by the New Panama Canal Co., and their thorough technical investigation of the engineering problems presented by

the canal undertaking across Panama, by which a reliable estimate of the further outlay of time and money involved therein has been arrived at, the question arises whether it may not be opportune to reconsider the whole attitude of Great Britain towards the improvement, or, strictly speaking, the perfecting of the westerly trade route by the forging of a single key or a duplicate key thereto. We have, humanly speaking, assured the construction of the Nicaraguan Canal by the United States within the next few years to the inevitable preferential benefit of American commerce throughout the Pacific, the contingent rapid development of her carrying trade and sea power, and the commensurate decline of our own commerce, carrying trade, and sea power throughout the same area and possibly everywhere else, for the sake of the benefit accruing therefrom to Canadian commerce, which the Dominion will commensurately share with the United States.

The Panama Canal can be completed for a cost not exceeding 21 millions sterling in such a way as to be, at least, as serviceable as the Nicaraguan Canal for trade purposes. The United States is irrevocably committed to the Nicaragua scheme for political reasons which have absolutely secured to them the effective control of this route without any chance of outside interference, *i.e.* the interference of any European power. The completion of the Panama route will cost less, and possibly only two-thirds of the eventual cost of the Nicaraguan route, for the technical data on which the estimates in the former case are based are far more conclusive and exhaustive than is the case with the various estimates for the latter, and more likely to be correct. A preponderating control over the Panama undertaking could be acquired with greater ease than was the case with the Suez Canal, and by analogous means. The effective control of the Panama route by the sea power as distinct from the land power of any nation would be far more feasible than that of the Nicaraguan route, the length being only 46 miles against 170; while, finally, only the steadily waning sentimental interests of France in the one case have to be reckoned with, as against the ever-growing material interests of the United States in the other.

Putting the case in plain business-like language, our most formidable trade competitor in the Pacific, and, let us add, probably the most formidable in the world ere long, who has just become a great Colonial power, as the conqueror of the lost Spanish over-sea possessions, is on the eve of systematically expanding their carrying trade and sea power to correspond with the already vast expansion of their manufactures and commerce. This rival has secured the exclusive military and commercial control of the key to the only possible competing route to the great easterly trade route from Europe to Australasia and the far East. The possession of this key will, at one and the same time, furnish the means and the incentive to readily and adequately expand their carrying trade and sea power to the dimensions to which they aspire. If the possession of this key is to remain exclusively in the hands of our most formidable trade rival in the coming century and is made the most of, as it inevitably will be, for the exclusive benefit of American trade, by every device and resource which are open to the notoriously far-sighted but unscrupulous fiscal policy pursued by the United States government at the bidding of magnates of American manufactures, what is the probability of Great Britain holding her own in the Pacific area, which will have been placed within the limits of the neutral competing zone for sea-borne commerce on the American side? Plainly, in view of the other existing elements handicapping British manufactures and trade in favour of America, the chances of our holding our own will be of the slenderest description, and one fine day we shall probably awake to find our carrying trade also gone beyond praying for, not only in the Pacific but on the other great oceans of the world as well, and our sea-power must quickly follow. If our Pacific trade alone were at stake, a trade amounting in the far East and the Pacific coast of America to 5 per cent. of our total foreign trade, and with Australasia to at

least 33 per cent. of our total Colonial trade, or directly one-eighth and indirectly one-quarter of our total external trade, it seems to us that it would be folly not to make an effort to complete and control the alternative Panama route, if by so doing we could minimise the disadvantages which the exclusive American control of an only key to the great westerly trade route of the world's commerce must inevitably involve. If the teaching of history be once more appealed to, and it be considered that commercial rivalry has been the real if not always the ostensible cause of all the great armed conflicts which the world has seen, what will be our fate if our trade rivals possess the further strategical advantage which the exclusive control of a water-way across the American isthmus must confer on their sea-power? Our chances of maintaining that sea-power, on which our very existence as a world-power depends, would become as short-lived and evanescent in the event of a conflict with the United States of America as those of maintaining our commerce and carrying trade in the Pacific after the opening of the Nicaragua Canal under their commercial control will be. But we could undoubtedly, to a large extent, discount the commercial and military disadvantages under which we shall have to labour by the construction of the Nicaragua Canal under the conditions we have agreed to, were we to secure the construction of the Panama Canal as well, and were we to take such means as may be expedient to effectively control it in the interests of our Pacific commerce and carrying trade after it is built. This could be done by British capital investing in this undertaking to the extent of some twenty million sterling. Will our government, or, failing that, our capitalists, have the foresight to seize the present unique opportunity, which most certainly will never recur, and, availing themselves both of the financial straits and uncertain future of the French Company and the exclusive pledging of American interests to the alternative isthmian route, take the necessary steps to secure the former for Great and Greater Britain?

Steel Rails.

VARIOUS conflicting statements are made as to the reason for the success which attends foreign manufacturers in obtaining orders for rolled steel rails in this country. Technical and other journals are more or less occupied in publishing articles upon this subject. Some of the writers responsible are doubtless well-informed, while others evidently know very little of the matters on which they discourse. Three classes are usually singled out for blame—the masters, the men, and the railway companies. Of the first class it is frequently said that they are deficient in technical knowledge, and in proper machinery and labour-saving appliances. So far as steel-makers and rolling-mill proprietors are concerned, we do not for one moment admit the justice of this accusation, as we have more than once stated in these columns. Of the second class it is said that the rate of wages is too high, the hours of labour are too short, that there are too many holidays, and that undesirable habits are too prevalent. We do not find fault with the rate of wages existing, but it is perhaps open to doubt whether the production has grown with increase of pay, and it is unfortunately the fact that the men are not willing to earn as much money as the rate of pay permits. This is certainly an undesirable feature, and one that cannot be advantageous to anyone concerned. Of the third class, it is constantly urged that freight is unduly heavy for home productions, and too low for foreign productions. No doubt readjustments are required in this matter, but the hardship now existing is not sufficient to account for successful foreign competition. Many amiable and well-meaning people talk of technical education as a sort of universal panacea for the cure of all British trade disabilities. Moral education might have the effect of inducing men to perform a good day's work for a good day's wage, of curtailing unnecessary holidays and bad habits; and it might result in the reform of Trades Union abuses; but no one in his senses can expect technical education

to exert the slightest influence in this direction. Neither is it likely to affect the question of railway charges. It is a significant fact that steel makers are not wanting who accuse some of our most highly educated civil engineers of practices that constitute a direct aid to successful foreign competition. In the opinion of more than one steel manufacturer a most important point, and one consistently neglected by the technical press, is the unreasonable and stringent specifications to which British steel makers are compelled to work. Such specifications are considered to be the means of admitting foreign competition into our markets, by retarding delivery and increasing the cost of railway material as manufactured in this country. As a general rule railway engineers fill their specifications with absurdly stringent conditions. They pretend to know more than the makers on the subject of steel making, and, in addition to the usual reasonable tests, they frequently demand that any further tests that may be demanded shall be carried out at the maker's cost. Arbitrary and irrational clauses in any specification always give rise to apprehension on the part of a manufacturer or contractor, and the logical outcome is increase of price and delay. Foreign firms almost invariably object to such clauses, and their protest is not infrequently allowed, whilst the penal conditions are maintained as against home producers. Another evil of the same class is that nearly every railway engineer thinks he knows better than his contemporaries what is the best section for rails, fish-plates and other auxiliaries. More than this, he insists upon the realisation of his pet theory. As a consequence, manufacturers waste much time owing to the constant change of rolls for different customers. Effective protests have already been made in some branches of industry against this irritating faddism, and we should be delighted to hear that the steel makers as a class had determined to put it down with a strong hand. All the engineers who demand special sections cannot be right, and there ought to be no difficulty in arriving at standard types for universal adoption both in rails and in sections of rolled steel for structural work. Our rolling mills must be kept as far as possible in continuous work, rolling similar sections week after week, adding to stock material not wanted for immediate delivery, and saving the prodigal waste of time now swallowed up by a frequent change of rolls. It would then be possible for stocks to be held with a reasonable confidence that they would constitute no undue burden, and manufacturers would be better able to meet demands for prompt delivery at practicable prices.

An American Verdict.

THE difference between contemporary notoriety and a claim to permanent fame is most strikingly illustrated by an experiment recently made by the Editor of the *Electrical World*, of New York, who has published three lists, based upon the votes of members of the American Institute of Electrical Engineers, who were asked to draw up lists of the 25 most distinguished electricians in the nineteenth century, and to assign to them places in these lists according to their merits. The first list was compiled from votes cast by the bulk of the members, *i.e.* by 300 of them. The second represents the votes of 25 of the "most prominent engineering members," and the third, the verdict of 25 of the "professors," or theoreticians. In all three lists Faraday occupies the place of honour, and Lord Kelvin the second or third place, while, in the two smaller lists at least, Maxwell also appears among the three leaders. The intellectual superiority of these three distinguished scientists, of course, could not but be comprehended by even the dullest minds. The places below these, however, have been filled by the voters in a manner that plainly shows that a member's ticket granted by one of the numerous professional societies does not necessarily endow the holder with sufficient knowledge to distinguish between plausible mediocrity and real proficiency, and which is one of the strongest possible arguments against trial by jury. The 25

"prominent engineering members" give to Siemens the seventh and to Helmholtz the ninth place; and among those above them we find Bell and — Edison! The latter, in fact, occupies the sixth place. The "professors" assign to the local hero even the fourth place. To fully appreciate the grotesqueness of Mr. Edison's proximity to Faraday, Kelvin, and Maxwell, all that is needed is to read in succession one of Kelvin's or Maxwell's brilliant scientific essays, and afterwards the chapter of Mr. Edison's autobiography, published in the form of an interview in the *Electrical Review*, of New York, issued on January 28th, in which we are made acquainted with Mr. Edison's main achievements in Mr. Edison's own inimitable language. The latter is in itself one of his achievements. Being asked to enumerate his chief inventions, he at first believed that he was to mention his chief patents. Of course, we all know that there is a world of difference between his patents and his inventions, and he himself appears to realise this.

"What were my principal patents?" he exclaims. "Good gracious, man! Oh, you do not mean patents—inventions? Why, first and foremost, the idea of the electric lighting central station; then—let me see, what have I invented? Well, there was the mimeograph, and the electric pen, and the carbon telephone, and the incandescent lamp and its accessories, and the quadruplex telegraph, and the automatic telegraph, and the phonograph, and the kinetoscope, and—I don't know—a whole lot of other things."

This, then, is the list of merits that, in the opinion of the American engineers, entitles Mr. Edison to a place near Faraday, Kelvin, and Maxwell, and far in front of such men as Helmholtz and Siemens! The vote of the 300 places him even higher than Maxwell; for their list begins with Faraday, Kelvin, and Edison, then follows Bell, and further down, long after Morse, Tesla, etc., we find Maxwell, Siemens, and—Helmholtz. When the history of science in the nineteenth century comes to be written, will it be based upon the vote of the American engineers? Heaven forbid! But where will be the names of the voters?

Marvels of Electrical Vibration.

THERE can be no doubt that the vast majority of statements attributed to Mr. Tesla in the press of the United States are—to use a mild term—inventions pure and simple. There has, however, appeared recently an interview with him, granted to Mr. Frank L. Perry, which is published in a respectable contemporary, namely, the *Western Electrician*, and which we may assume to be absolutely authentic. The bulk of it consists of predictions and forecasts regarding the probable line of progress of applied electricity during the present century. With these we have nothing to do. Predictions, whoever be their author, are illegitimate statements that must be met in a different attitude from that which we ought to take up regarding statements of fact. It happens, however, that in his conversation with Mr. Perry there occur at least two statements of fact of the highest interest, and these deserve our fullest attention. They are as follows:—

"With a small engine, capable of pressing a piston backward and forward with a force of but two pounds, I have set an entire block of modern buildings, by careful attunement, into such a swaying that the people rushed out affrighted. With an impressed force of a fraction of a pound I caused steel rings of several square inches cross-section, capable of supporting several hundred tons, to vibrate and form loops like thin piano wires, until they finally broke."

Theoretically, such an increase of active energy by multiplication and combination of oscillatory waves is, at all events, not impossible, and to doubt that Mr. Tesla actually accomplished what he says he accomplished would be an insult that nothing that is known of his work deserves. Moreover, unlike Mr. Edison, he does not work by rule of thumb, but is fully conversant with scientific laws. This being so, it appears that in the present century we may hope to witness applications of electricity that will put into the shade the most remarkable achievements of the past, and we sincerely trust that Mr. Tesla will soon see his way to give to the world the full data of his great discoveries.

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilisation's timepiece put back 200 years."—Rt. Hon. Lord Charles Beresford, C.B.

The Revival of Bristol Port . . .

For many years it has been the desire of the authorities to restore, as far as may be possible, the ancient glories of the Port of Bristol. Once ranking second to London alone, Bristol has fallen to the fifth or sixth place amongst the seaports of the United Kingdom. The reasons for this decadence are sufficiently patent to those acquainted with the domestic history of the past century. Before the inauguration of steam navigation the increasing tonnage of ocean-going vessels began to outgrow the accommodation afforded by the River Avon, and shipowners became increasingly averse to the use of a harbour whose natural disadvantages were particularly marked. Its most objectionable features were removed early in the century by the construction of the City Docks, commonly known as the "floating harbour," but the tedious journey from Avonmouth to the city still remained an unavoidable necessity. When steam was successfully applied to the propulsion of ships the shipping classes in Bristol were caught napping, and Liverpool secured the mail contracts between this country and the New World, and became recognised as the principal centre of the transatlantic traffic. Other ports, again, began to offer better facilities for dealing with merchandise, and further continuous increases in the dimensions of steamships took place from time to time. The City Docks were then no longer suitable for the changed order of things, and this fact was at last so strongly evidenced that more modern accommodation was provided by the construction of the Avonmouth and Portishead Docks at the mouth of the river. These, in turn, have been outgrown by still further shipbuilding developments, and at the present time steamers of the largest class are unable to enter the docks. Much discussion has taken place during recent years with regard to the best means of abolishing this disability. One party contended that the proper remedy was to close the mouth of the river, thus converting its whole course below Bristol into an artificial waterway, connecting existing and projected docks. Another party was in favour of leaving the river in its natural condition, and of adding new docks of ample capacity in the neighbourhood of Avonmouth. The latter policy has finally prevailed, and the sanction of Parliament will shortly be asked for the construction of extensive dock and other works at Avonmouth which, it is hoped, will do much towards the development of the western port. Other gratifying evidences of activity are to be found in the inauguration of a new line of Atlantic steamers between Bristol and the West Indies. The association of the port and the West Indian Islands is of very old standing, and it is a happy circumstance that these centres of industry are to be more closely united by a tie which cannot fail to exercise a beneficial influence on their future prosperity.

Protection for Agriculture . . .

It is no wonder that Count von Bülow's statement in the Prussian Diet,

foreshadowing a new import duty on agricultural products, has been the cause of fierce controversy in both German and foreign journals. Landed estates have been steadily reduced in value during the last few years, and their proprietors are becoming alarmed; for, if this decrease in value continues, they, or at all events their descendants, will be reduced to beggary. From an agricultural country Germany has become an industrial country, and the change, though seriously affecting one class of the population, has apparently been far from disadvantageous to the country at large, for *pari passu* with the decay of farming German industries and German commerce have advanced. The imports, which in 1893 amounted in value to £198,000,000, reached in 1900 the value of £278,000,000, and the exports rose from £155,000,000 to £221,000,000. But this apparent prosperity has its reverse, for Germany, like England, is no longer able to produce food on her own soil sufficient to nourish even a tithe of her population. As matters stand, in case she should be cut off from foreign imports—during a period of war, for instance—her people would have to face starvation. We, at all events, have our Colonies, which would supply us; and the United Kingdom, moreover, is accessible at so many places by sea that her isolation by an enemy is practically impossible. Not so, however, Germany; and this fact is used as an argument by the landed proprietors in Prussia, who are a very influential class, since most of them belong to the old nobility. Nevertheless, those who imagine that the agitation in favour of new import duties on agricultural products has patriotic motives are greatly mistaken. It is far too late for Germany to become self-supporting again, and such import duties, far from securing independence to her, would reduce her to ruin; since the nations that at present supply her with food would retaliate by prohibitive duties on her manufactures. This the promoters of the scheme for excluding foreign agricultural products must know. Their aim, therefore, is not patriotic, but selfish; their only excuse being that they are fighting for self-preservation. But we may well ask ourselves—Is there no way for countries like Germany and our own of regaining their former independence as regards the supply of food? To our mind, there is a way, and one only. Science, that has been so powerful an aid in industrial progress, must furnish us also with food in the future. Not so very long ago such a proposition would have been ridiculed, but at present we know that this solution is not only possible, but probable; and we are justified in hoping that in the present century, and perhaps in the near future, ways and means will be discovered for producing food in our chemical laboratories from other sources than from animal or vegetable matter. Such chemical food, from which water is entirely eliminated, though it may be added at any time, will moreover occupy so small a space that a year's provisions for the whole population can be stored in magazines, occupying a minimum of space, dispersed throughout the country; and in this way a blockade would become comparatively harmless.

The Institute of Marine Engineers . . .

For some time back considerable improvements have been introduced into the general work of the Institute of Marine Engineers. Better care is taken to sift the class of paper which should be read before the members at their ordinary meetings. The Council does not leave this matter to a committee, but makes its own selection, and its standard is rising year by year. Then, again, a committee was appointed to conduct experiments and investigate problems which arise in the ordinary course of the engineer's work. This was a very desirable field to open up, and the Institute did well to encourage in every way possible the members of that committee to pursue successfully the course which they had laid down for themselves. Several reforms have also been made in the management. Formerly the work of the Institute was entirely of an honorary nature. An honorary secretary and honorary treasurer and convener of sub-committees conducted the work. But the work of the Institute increased, their

own premises were obtained, and, with a membership of about 1,200, it soon became evident that the work could not be satisfactorily done by voluntary methods in the houses of the secretary and conveners. The next obvious step was taken, and a paid secretary was appointed. A few other modifications in the working arrangements of the Institute might, however, be made to advantage. To begin with, they might do worse than keep minutes, and read them and have them passed at their ordinary meetings. It is a small reform, but it means a good deal. Then, secondly, a ballot of any new members might also be taken in the ordinary meeting, and not in the council as heretofore. The less the council of any institution takes upon itself the better, and the question always remains as to whether any decision come to by a council is binding on the members. Then, again, it cannot be denied that when the council of an institution knows it has the support of the membership—as it would have if it submitted its proposals to an ordinary meeting—it would feel itself much stronger to act. Then there is the place of the meeting. The headquarters of the Institute are supposed to be at Stratford. But is it quite fair to the London members to hold meetings at a place where it is quite impossible for them to attend? Is it fair to members of the Bristol Channel and other distant centres to expect them to run down to Stratford to the library any time they run up to London? Sir John Gunn, we know, has taken up the question of a real centre and meeting-place in London proper, and he and the strong, vigorous body of members at his back in the Bristol Channel centre seem likely to see the matter through.

Engineering Education . . .

ATTENTION is now being directed to this subject in more than one direction. Various well-known public men have, within the last two or three months, urged the necessity for the modification of existing methods and for the extension of educational advantages of a kind most suitable for equipping the rising generation for the battle of industrial life. One of the first indications of a practical movement towards this end has been made by the India Office in connection with Cooper's Hill College. On the face of things it seems an encouraging novelty that a Government department should lead the way in a matter of reform, but unfortunately serious doubts are prevalent as to whether the alterations in progress have been wisely instituted. We are not in a position to express any opinion one way or the other. The change of policy at Cooper's Hill is severely criticised by a number of the most distinguished scientific men in the kingdom, who are unanimous in asking that an inquiry should be made into all the circumstances. Lord George Hamilton, representing the India Office, sees no necessity for any such investigation, stating that the Government had acted, as they believed, "in the interest of the country, and in reliance on the highest authorities whom they could consult." Greater attention is in future to be devoted to the teaching of engineering, and especially of electrical engineering—a subject hitherto very much neglected at the institution in question. The hours of work are to be increased, the standard of entrance examination is to be raised, and efforts are generally to be made with the object of increasing the practical value of the training to students. This is a most laudable programme, and one that must commend itself to all. The point is whether the seven dismissals from the teaching staff are justifiable. If the gentlemen dismissed have in any way constituted themselves obstacles to progress, then the India Office may be sincerely congratulated for their moral courage in undertaking a painful, though necessary, duty. In the interest of all concerned, it now seems desirable that the public should be able to learn the whole circumstances, and especially since the action of the Government has been challenged by a body of men whose names are so justly honoured by the nation and the world at large.

Improved Railway Couplings . . .

ALTHOUGH the Board of Trade, in virtue of the Prevention of Railway Acci-

dents Act, of 1900, is entitled to enforce the adoption of automatic couplings, it may be doubted whether such a course will be taken. Some people may wonder why railway companies should be excused from what appears at first sight to be an obvious duty, but the question is fraught with difficulties. Automatic couplings, and similar apparatus used on American railroads, are in many cases entirely unsuitable for British railways owing to the different conditions prevailing, and there are weighty reasons why our system cannot be altered. Without entering upon technical objections, it may be at once said that the financial obstacles in the way of such a revolution are practically insuperable. Under these circumstances, the best thing to be done is to bring the non-automatic coupling to the most perfect condition possible. The attention of railway engineers has been devoted to the subject for some time past, and there seems to be some reason for hoping that in its latest form the invention of Mr. E. J. Hill may be found worthy of general adoption. By the aid of this apparatus the coupling pole, usually carried by the shunter can be entirely abolished, as the work is performed by a lever permanently secured to the waggon; one end being attached to the middle link of the coupling, whilst the free end is fitted with a wooden handle at a convenient height from the ground. In the act of coupling two trucks the handle is pressed in a downward direction and the link is thereby raised above the hook, upon which it is then dropped. In uncoupling, the handle is pressed far enough to disengage the link, and the chain is allowed to fall free of the hook. No previous experience is necessary, and the whole operation can be performed with one hand, the other being available for holding the lamp which is generally an adjunct to shunting work. We believe that several railway companies are now making practical tests upon the device in question, which, in addition to simplicity, possesses the advantage that its application involves a merely nominal expenditure per waggon.

Rapid Transit Tunnel, New York . . .

ALTHOUGH described as a tunnel, the rapid transit railroad now under construction in New York will only be laid for a distance of about three miles in a tunnel proper. The remaining part of the underground road will be in a subway formed on the cut-and-cover system. In sections where tunnels are to be driven through solid rock, they will pass beneath the surface at a considerable depth, particularly below Washington Heights, and in that district the average depth will be about 120 ft. At 181st Street the station is to be 120 ft. below the street level, and it will consist of an excavated chamber having a roof in the form of an elliptical arch. Access will be afforded by two lifts of exceptionally large capacity, and a staircase for use in the event of accident to the machinery. In one portion of the line the excavation approaches nearly to the surface in consequence of a natural depression of the ground. Therefore, for a distance of about 600 ft., open excavation will be adopted, and after the steel framing of the subway has been built in position the roadway will be restored to its original condition. Very satisfactory progress appears to have been made in connection with tunnelling operations, and two out of several projected power stations for working pneumatic rock-drills have already been erected. In respect of actual excavation by the cut-and-cover method, that part of the line on Fourth Avenue presents no difficulties, as the material is loose, sandy soil, readily removable by pick and shovel. Some trouble has risen, however, because of the necessity for cutting away all the material underlying the metals of the Metropolitan Street Railway Company without interfering with the working of the line. The problem of supporting the tracks whilst removing the material was by no means easy of solution, but the task was accomplished by the aid of massive I-beams, spanning the portion to be excavated, and supported by timber false-work. After excavation, the steel framework of the subway walls and roof was erected, when the false-

work could be removed, and the concrete arches be turned between the steel framing. Four layers of felt and tar waterproofing are laid completely round the concrete, and an outer sheath of brick and concrete is formed over the whole subway. Upon this the loose material is filled in, and the street is restored to its original condition.

Germany's Naval Ambition . . .

IT was one of the striking peculiarities of Prince Otto von Bismarck's diplomacy to state bluntly and unreservedly what he intended to do beforehand; and this appeared to be so improbable a proceeding to other diplomatists, who tried to excel each other in dissimulation, and were brought up with the idea that the art of hiding one's intention is the most important qualification of a diplomat, that they naturally assumed the wily Chancellor would act in direct opposition to what he had declared to be his aim. And when, to their amazement, they later found that Bismarck had actually carried out his avowed intention, did they take him at his word the next time? By no means; they now argued that the first manœuvre, clever though they acknowledged it to be, would certainly not be repeated. It had succeeded, because the great schemer had justly foreseen that his avowed intention would naturally be disbelieved; but if they should take the second announcement of the "honest broker," as he called himself, to contain the truth, he would surely have the laugh against them. They were, however, again beaten, and again had to grant that the German statesman's genius was excelled only by his audacity. Still, the next move must obviously be a blind. Nothing was clearer than that what Bismarck had foretold this time was intended to hide a deep scheme; they only asked themselves what was his real intention. Some were in favour of one solution, others foretold a different *dénouement*. None of them guessed correctly. Prince Bismarck strictly followed the lines he had made public. Again and again the game was repeated, and again and again the Chancellor scored. When all are dissimulating, there is no better way to create distrust than speak the truth. To some extent, telling the truth, with the intention of deceiving, has become a characteristic of German diplomacy, and other countries will do well to count with this factor. What seems more improbable than that Germany—that continental country which, until quite recently, had no Navy whatsoever, and, of all her neighbours, is least favoured by nature as regards dominion on the seas—should actually aim at the establishment of naval dockyards, not for her own requirements only, but, as the "Internationale Revue über die gesammten Armsen und Flotten" openly announces, to "supply many foreign countries." Is this mere "bluff"? Is it megalomania, a symptom of mental paralysis? Nothing of the kind. We will do well to take our friends across the North Sea at their word. Their transatlantic liners show what they can do when entering the arena of competition, and let us not forget that Prussia, which holds the hegemony of the empire, developed her power with the initial capital of a sandy desert, a stretch of territory which yielded the barest sustenance merely as the price of incessant and arduous labour. Where energy and knowledge are added as working capital to the barest pittance, success is far more certain than where nature's lavish gifts permit enjoyment without effort, or where past glory invites us to slumber in security, and renders us liable not to awaken until long after a new day has broken, and all around us we perceive that the scene has changed. The achievements of the nineteenth century should warn us that this is no age for rest. The twentieth belongs to men with open eyes. Ours is an era of work and action. *Répos ailleurs!*

Problems of Science Teaching . . .

THE remarkable development of scientific knowledge during the century which has just closed, and the probability that this development will continue for many years to come, naturally forces upon

us the question in what manner the enormous amount of accumulated learning and the immense area of research opened up by the great thinkers of the departed era can be rendered available to the student who shall select physical knowledge, theoretical or applied, as his special field of work. There can be no doubt that the methods of academical teaching of science both in the universities and in the technical high-schools will have to be modified to some extent, and, in fact, such modifications can already be perceived, both in the United States and on the Continent. In most cases these modifications have the tendency, not so much to increase the amount of knowledge obtainable in our great educational institutions as to render it useful and applicable to practical purposes. To a certain extent this is due, it cannot be denied, to the commercialism of our age, which places a high value—too high, indeed, in the majority of cases—upon the immediate money-earning capacity of knowledge and does not look kindly upon the acquisition of knowledge for its own sake. Commercialism, however, is not the only cause of the transformation in our teaching methods which emphasise practical teaching at the expense of purely theoretical teaching, for a powerful influence in this direction must be attributed to the drift of Kantian and post-Kantian philosophy both on the Continent and in Great Britain, which has effectively reduced to a minimum speculations regarding the unknowable, and taught the present generation to concentrate their energies upon what lies within the limits of reason with the object of increasing the well-being of mankind. Not that metaphysical speculations have been abandoned entirely. They cannot, and ought not to, be abandoned; but, at all events, common sense has taught our generation that there are more immediate duties which deserve precedence—the duties of daily life—and that the right of dreaming has to be earned and belongs to leisure hours. These leisure hours will increase in number if we do our share in rendering mankind more and more independent and assist in the work of progress, which is to reduce to a minimum the efforts required to obtain the bare necessities and the modest comforts of life, so as to be able to devote the bulk of our time to the pursuit of higher aims. The time when people looked upon those as sages and saints who spent their life in idle contemplation and meditation, while they left to the working portion of humanity the task of feeding them—claiming, in fact, sustenance from the industrious portion of their fellow-beings as a right—has practically ceased to exist in the western world. Labour is no longer treated as a heaven-ordained punishment, but as a noble duty, thanks to the "Critique of Pure Reason," and to such men as Mr. Herbert Spencer, who rendered philosophical truth accessible to the many. This being so, it is natural that practical education should be in higher favour at present than purely theoretical learning. There is, however, a certain danger in our present mental attitude; for many among us imagine that what is not of immediate market value is useless, and forget that, for instance, a thorough study of theoretical science in one century is often the sole and necessary source of the practical achievements of the next. It would, therefore, be a serious and inexcusable mistake not to encourage those who have special gifts and great intellectual powers in their desire to devote themselves to a purely academical life, and to labours of research and discovery. We should never forget that an apparently insignificant scientific achievement has often been, and at any time may be, the cause of most far-reaching progress for humanity at large. Bearing this in mind, the problem of scientific education will always be two-fold, namely, the problem of aiding scientific research for its own sake, and the problem of encouraging scientific studies with a view to the application of science. In the solution of both problems the achievements of the nineteenth century will have to be taken into consideration. These achievements have been—as has been shown more fully in a former number of this magazine—pre-eminently in the direction of unification and of removing

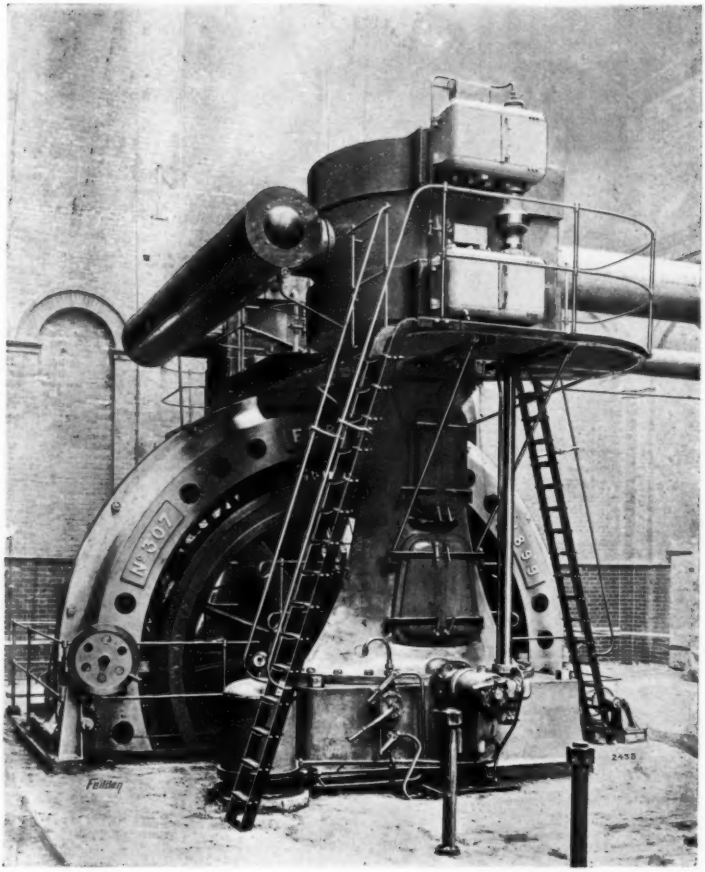
the artificial limits formerly separating the various branches of physical science ; and we have reached the conviction that no specialist in any one of these branches will make much progress unless he has a fairly good general grasp of the essential features of the other branches. To take only one instance, but perhaps the most important of all, of the consequences arising from the above-mentioned unification of science, let us dwell for a moment on the position of the chemist of the future. Chemical science, formerly treated as an entirely separate field of natural science, has been entirely revolutionised since the unnatural barriers that separated it from physics have been removed, and both sciences have become so closely interwoven in recent times that the knowledge of one can no longer be complete, even in mere outline, without some knowledge of the other. Chemical physics is a child of the nineteenth century, and electro-chemistry has already grown to such an extent that its study will be taken up by thousands within the near future as the source of the keenest intellectual enjoyment, and will secure material benefits, both directly and indirectly, to hundreds of thousands. It is entirely useless, however, for the future electro-chemist to confine his studies of physical science to merely that portion of physics which deals with electrical phenomena, or perhaps to a study of a selected part of electricity only. If he desires not to be hampered in his progress he must have a full grasp of physical science in general ; for at any moment he may have to look for an answer to some question arising during his experiments in the magnetic theory of atoms, or in the phenomena of incandescence, or in the theory of waves and vibrations, or in the laws ruling the phenomena of heat. Specialisation, therefore, is growing more and more impossible during the important period of academical education, and must be left to the years subsequent to this period. In consequence of this very fact, however, it is absolutely necessary—unless the course of instruction at the university or technical high-school is to be unduly prolonged—that a modification should take place in the very subjects of instruction. To teach a science, or any branch of a science, within the few years of academical study has long ago been recognised, especially in Germany, as an impossibility, and grows to be a more and more absurd undertaking the more the state of knowledge accumulates. Facts can be found at any time in the many works on science that are annually published, and are, moreover, an indefinite and ever-increasing quantity ; theories have a value merely as a mnemonic aid, but, of course, their study is instructive. The groping towards light which they represent frequently shows in which direction the path lies. Truths, however, are permanent, and these truths of science must form the chief subjects of teaching, together with the methods by which they were obtained and by which their number can be increased. The true and most important aim of academical instruction, therefore, must be to teach those who wish to devote their life to theoretical or practical science "how to study," leaving it to themselves to find the material for their work, to train them in using their faculties, to show them the directions in which search must be made for greater light, and to send them into the world endowed with a correct view of what has been achieved and the knowledge and comprehension of the means to be used for further achievements.

ENGINEERS are invited to communicate to the Editor of FEILDEN'S MAGAZINE the result of their investigations in any field of Industrial Progress. If suitable, an original account of the improvements which they have effected in any branch of Manufacturing Industry, New Processes which they have discovered, or Inventions which they have brought to a state of commercial value, will be published over the signatures of the contributors, and high-class engravings produced free of cost to the writers, which will be employed to illustrate the articles.

The unparalleled publicity which FEILDEN'S MAGAZINE affords to anything new which appears in its pages, will thus be of the greatest value to the contributor, whose investigations will be brought prominently before the engineering and industrial world.

SUP

Supplement to
FEILDEN'S MAGAZINE
March, 1901.



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AT THE SOUTH LONDON ELECTRIC SUPPLY CORPORATION'S WORKS,
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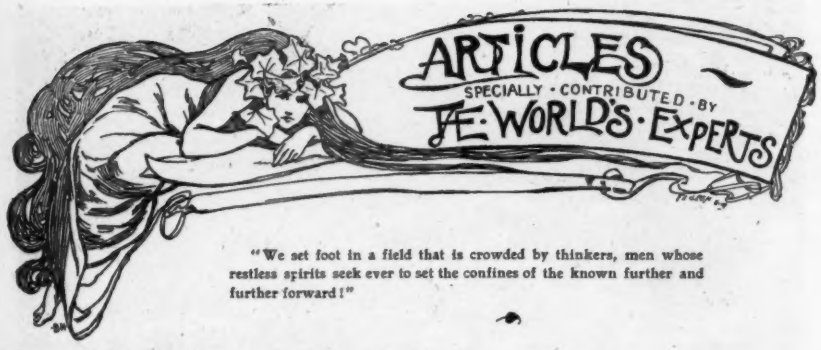


"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

The Development of the White Lead Industry.

By L. M. G. CUTHBERTSON, F.C.S.

MR. LIONEL M. G. CUTHBERTSON is a son of the late Dr. Francis Cuthbertson, M.A., LL.D., a distinguished mathematician, and was born in the year 1873. He was educated at the City of London School, and after matriculating at the London University and studying at the University of Wales, Aberystwith, entered, at the age of nineteen, into the firm of Lewis Berger & Sons, Ltd., the well-known colour and white lead manufacturers. He worked for two years in their laboratories at Homerton, then went as analytical chemist to their Sheffield house, and for some time acted as manager of their white lead works there, during which time, in conjunction with the late Mr. Wm. Thorp, B.Sc., F.I.C., etc. (the leading authority on white lead manufacture), he carried out successfully a series of large-scale experiments for the quicker and more efficient manufacture of white lead. Subsequently Mr. Cuthbertson came to London some eighteen months ago to manage a new and ingenious white lead process by precipitation, in which method of manufacture he believes there is a big future.

NEARLY all important trades have been evolved from a humble origin, and have improved and developed until the process is more or less perfect. Often the development is very rapid, and a few years will suffice to transform a small-scale manufacturing operation into an important and wide-spread industry. An increased demand tends to greatly modify the process of manufacture, and all that science and ingenuity can do to hasten and improve the production is quickly adopted.

White lead, however, is remarkable for not following this general rule, for though its output and consumption have multiplied to an enormous extent, the improvements in its manufacture have been, until within the last year or two, practically nil.

Yet there is a fascination about the history of white lead. Its ancient origin, its peculiar and unique properties, its ubiquity, its utility as a pigment, and the conservative method of its manufacture, all tend to make the study of this indispensable product one of peculiar interest.

FIG 1.—LEAD REFINING HOUSE AT MESSRS. FOSTER, BLACKETT AND WILSON'S WORKS.

White lead is the white paint par excellence, and is universally employed in oilpainting, whether for domestic or artistic purposes: the coach-builder, the house-decorator, and the artist all strive to secure the best brand of this unrivalled white. It forms the basis of nearly all the common colours, giving to the pigment that body and covering power so much desired. The most peculiar feature about this remarkable pigment, however, is its mode of manufacture; for though white lead making was practised centuries ago, and to-day ranks as an industry of universal importance, having in England alone a consumption of nearly 80,000 tons per annum, yet, in its general principles of manufacture, it shows no advancement on the methods employed by our forefathers, who established their factories upon principles formulated by the ancients over two thousand years ago.

This process to-day is known as the Stack or Dutch method, and is that most generally adopted, and, notwithstanding the huge strides of science and the perfection of modern machinery, remains one of the crudest and most primitive of all industrial operations. To realise what little progress has taken place during all these centuries, it is only necessary to compare the old methods practised with the present mode of manufacture, and to note the absence of any serious effort towards improvement. This century, however, will see the long-delayed advancement; modern improvements are now at last being instituted, and the old apathy and conservatism will rapidly disappear.

(1) HISTORICAL SURVEY.

White lead, formerly known as "cerussa" or "ceruse," is mentioned by many ancient writers. Theophrastus, Vitruvius, Pliny, and Dioscorides, all describe its manufacture, but in each case the directions are similar. Pliny directs that metallic lead

in the form of shavings be placed over a vessel filled with strong vinegar, when, in due course, the surface will become coated with a white powder which can be scraped off. There is little doubt that this was the method generally employed by the ancient Greeks and Romans, though the writers in those days copied one another to such an extent that very likely the recipe may have been copied but not verified by actual production. The evidence, in fact, that white lead was used by the Romans for decorative purposes is purely literary, and is uncorroborated by archæologists and chemists. Davy, who analysed samples of paint from several tombs, asserts that he found no white lead in any of the white pigments scraped from the remains. It is more than likely, however, that white lead was used as a cosmetic (either as a white face-powder or tinted with coloured juices), a use to which it was probably put until quite recent years, for it is mentioned as an aid to beautifying the face by the poet Byron. After the fall of the Romans, a long time elapses before we can again take up its history. The manufacture of white lead was known to the Arabs, and is mentioned by Geber. The "dark ages" put a stop to any form of industrial progress, and the monks alone dared practise anything pertaining to the scientific. With civilisation at a standstill, the demand for a product like white lead would naturally be very small, and what was required emanated from the laboratories of the monks, who, up to the 12th century, were doubtless the sole producers. With the advent of brighter times, however, and the grand revival of learning, there was a sudden increase in the demand for this important pigment; for white lead, or "ceruse," has always been the white pigment universally used for oil-painting. As a result of the renaissance, Italy became the headquarters and recognised leader of things artistic, and it is therefore not surprising that we

FIG. 2.—MECHANICAL CASTING ARRANGEMENT AT MESSRS. LOCKE, LANCASTER AND CO.'S WORKS.

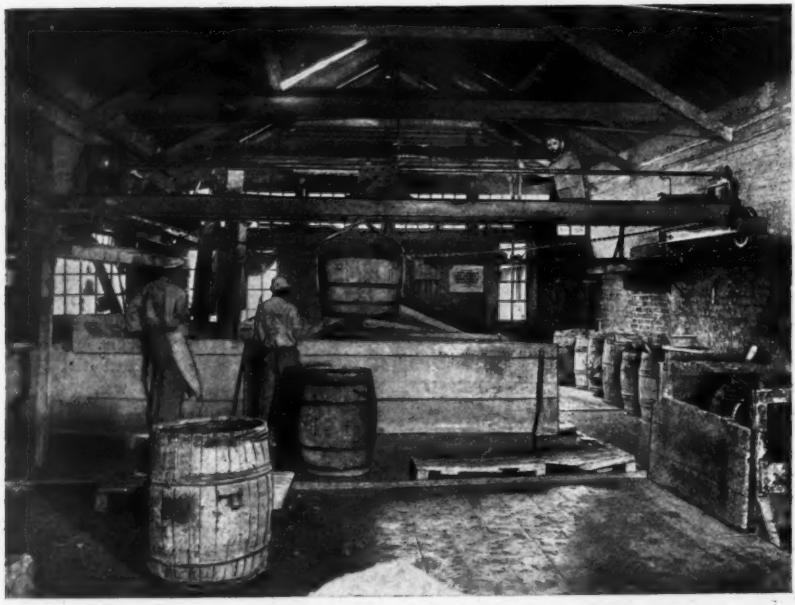


FIG. 3.—OVERHEAD TRAVELLING CRANE FOR CONVEYING THE CORROSIONS AT MESSRS. LOCKE, LANCASTER AND CO.'S WORKS.

soon find the Venetians monopolising the manufacture of this indispensable product for all artistic and decorative work. Most of the painters in these early days prepared their own pigments, over which they appear to have taken great care and pains to obtain the finest article. On this account the white lead from Venice soon gained the reputation of being the purest that could be procured, and until within recent times was noted for always being quite innocent of adulteration.

Mrs. Merrifield, in her "Original Treatises," gives translations of various MSS., in which, amongst other matters, are contained recipes for making white lead, which throw much interesting information on the methods adopted by the Venetians. The methods described, however, are always very similar, and show very little improvement on those of the old philosophers. Thus Petrus de S. Andema, whose MSS. the authoress ascribes to the end of the 13th century, directs that strong vinegar be poured into a vase, over which strips of lead suspended on twigs are placed, and the vessel then closed and sealed, so that "the vinegar may not exhale," and finally the whole covered with horse-dung. "After 20 days, on account of the acidity of the vinegar, the lead will be found to be turned white."

Another Italian—Eraclius—takes plates of lead and puts them in a jar filled with strong vinegar, covering the whole up, and leaving it in a warm place, where it remains for a month.

Another writer of the 15th century directs that leaden plates should be suspended over the vapour of strong vinegar, which, after being luted, must be placed in dung for two months, when white lead will be formed upon the plates and can be scraped away, when the lead is exposed once more.

It is remarkable that in all these descriptive accounts of the ancient writers, there is no attempt to give any chemical or philosophical explanation of the changes which take place, and the most noticeable

omission is the lack of any reference to the source of carbonic acid gas, which is the chief factor in producing white lead. The Italian writers certainly mention dung as a source of heat, and from this carbonic acid gas would be evolved, and would attack the lead. Then, too, the crude vinegar employed would probably contain fermentable substances, which would, by decaying, evolve carbonic acid gas; but, though the product would doubtless contain a considerable amount of acetate of lead, white lead would nevertheless be formed, even if we did no more than follow the instructions of the very earliest writers; for, supposing that there was no fermentable matter in the vinegar, or in the heating material, a plate of lead, coated with a film of acetate of lead, will absorb carbonic acid gas from the atmosphere around it, and will soon become coated with a white film of basic carbonate.

It was not until the sixteenth century that the Venetians had any rivals in the manufacture of white lead, and then the Dutch took it up; and though the method to-day bears their name as the "Dutch or Stack" process, yet they only adopted the methods known to the Venetians three centuries before, who in turn copied the principles laid down by Theophrastus, Pliny, and other ancient writers. The Dutch took up the manufacture solely because it appealed to their commercial instincts, and, with the object of taking the trade from the Venetians, with characteristic "slimness" they commenced a system of adulteration which enabled them to sell very much cheaper. The admixture took the form of chalk or barytes, and finding the easy adulteration very lucrative, and the demand increasing, several manufactories sprang up, and the output in Holland soon exceeded that in Italy, though the Venetians still retained their good name for purity. Germany next commenced to erect factories, though they afterwards abandoned the Dutch

FIG. 4.—PNEUMATICALLY FED PRESSES AT MESSRS. LOCKE LANCASTER AND CO.'S WORKS.

FIG. 5.

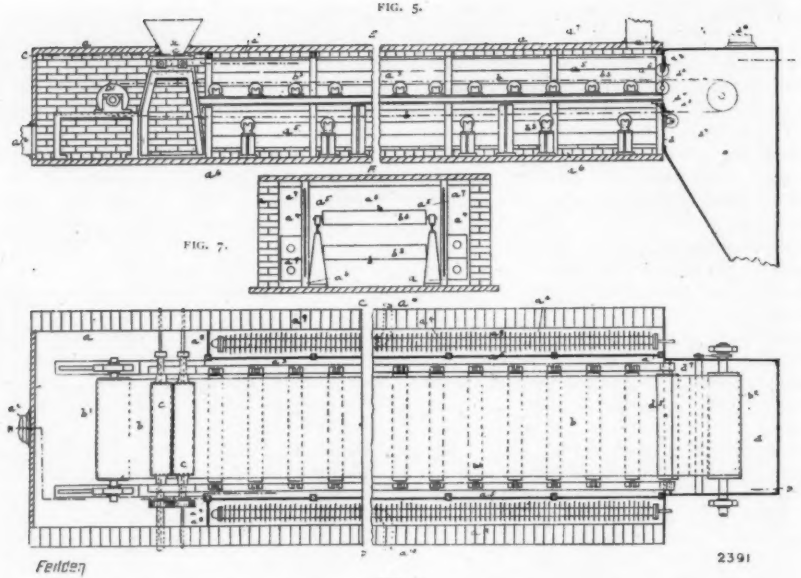


FIG. 6.
SANDERSON'S APPARATUS FOR DRYING WHITE LEAD.

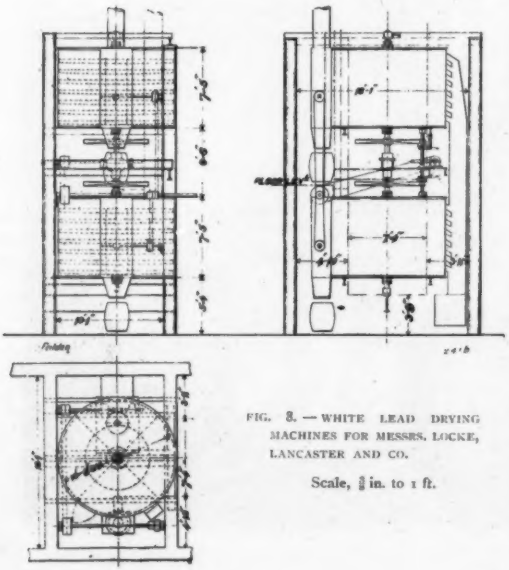


FIG. 8. — WHITE LEAD DRYING MACHINES FOR MESSRS. LOCKE, LANCASTER AND CO.

Scale, $\frac{3}{4}$ in. to 1 ft.

method for what is known as the chamber process, which to-day they universally employ. It was not until the early part of the seventeenth century that England established white lead factories, and subsequently France, Belgium, and America took up the manufacture.

(2) THE MODERN METHOD OF WHITE LEAD MANUFACTURE.

White Lead is a hydrated basic carbonate of lead, or a combination of lead carbonate with lead hydroxide, represented by the formula $2PbCO_3$, PbH_2O_2.

It results from the combined action of acetic acid, air, water, and carbonic acid upon metallic lead. Only the best refined metal, free from all impurities, and containing not more than ·0005 per cent. of silver, should be used. The blue (metallic) lead is melted, cast into suitable

form and transferred to the stackway. The latter, which is the principal scene of operations, is so called because it comprises a number of stacks, where the corrosion, or the conversion of blue into white lead takes place. The chemical changes which occur there are represented in the following equations :—

(1) $Pb + H_2O + O = Pb\,H_2O_2$.

(2) $Pb\,H_2O_2 + H_2\,(C_2H_3O_2)_2 = Pb\,(C_2H_3O_2)_2 + 2\,H_2O$.

(3) $Pb\,(C_2H_3O_2)_2 + 2\,Pb\,H_2O_2 = Pb\,(C_2H_3O_2)_2\,2Pb\,H_2O_2$.

(4) $3[Pb\,(C_2H_3O_2)_2\,2\,Pb\,H_2O_2] + 4\,CO_2 = 3\,Pb\,(C_2H_3O_2)_2 + 2\,[2PbCO_3\,PbH_2O_2] + 4H_2O$.

A careful study of the above shows the operation to be a continuous one. The normal lead acetate combines with lead hydroxide, forming a basic lead acetate. This is decomposed by carbonic acid gas, yielding basic lead carbonate (white lead), and normal lead acetate again, which is ready to take up more hydroxide once again, and repeat the cycle of changes.

The materials required, therefore, to make white lead are blue (metallic) lead, acetic acid, moisture, oxygen (obtained from the air) and carbonic acid gas (obtained from spent oak bark or tan). The conversion takes place in a stack, a rectangular space enclosed with walls—some 20 ft. high—having an opening in front forming a passage in and out of the stack. A series of such stacks, on either side of a gangway constitutes a stackway. Each stack is made up of a number of beds, which in practice are built up as follows :—A layer of spent bark, obtained from the tannery, is first spread on the bottom of the stack, some 18 ins. thick. On this are placed, side by side, earthenware pots, filled with dilute acetic acid. On the pots, but not in contact with the acid, is laid the lead, cast in the form of gratings or perforated plates. Over this, resting on wooden bearers, are placed boards, covering the whole in. This constitutes a bed, and on top of this is built another bed, and so on, until the stack is full—10 or 12 beds—when the stack is closed by placing a final layer of bark on

FIG. 9.—PACKING WHITE LEAD UNDER FAVOURABLE CONDITIONS AT MESSRS. FOSTER, BLACKETT AND WILSON'S WORKS.

FIG. 10.—APPARATUS FOR COLLECTING WHITE LEAD DUST AT MESSRS. FOSTER, BLACKETT AND WILSON'S WORKS.

the boards covering the top bed. The opening in the front of the stack is boarded up, and the whole stack left undisturbed for three months, the minimum time in which the conversion can take place. At the end of twelve weeks the stack is taken down. Each bed is stripped of its covering of boards, and the corrosions or transformed blue lead, the greater part of which has been carbonated into white lead, laid bare, and carried away in trays to the rolling chamber. Here the white lead is separated, by means of rollers, from its core of blue lead, for the corrosive action seldom penetrates right through the lead casting. The blue lead, or "returns," is melted up and recast, and the corroded white lead is levigated through a series of mill-stones, collected in tanks, filter pressed, dried in stoves, and packed in casks ready for the market.

It will be noticed that the whole of the blue or metallic lead which is put on the stack is not corroded.

The "returns," or blue lead uncorroded, having to be remelted and cast, and undergo the operation a second time—this, of course, is a large loss, and the object of the stackmaker is to get as low a proportion of returns as possible. A good stack properly built, under favourable conditions, should not yield more than 10 per cent. returns, while a bad one often shows as much as 50 or even 60 per cent. metallic lead uncorroded.

When once the stack is built there is no possibility of correcting any errors, or even of gauging how the conversion is proceeding, unless the stack indicates a very low temperature, in which case the result will inevitably be bad. The whole result depends on *how* the stack is built, which, as it is usually more or less by rule-of-thumb methods carried out almost entirely by unskilled manual labour, generally shows a much larger percentage of returns than is desirable. To get satisfactory results, many things have to be considered. Great care must be taken in casting the lead, which generally takes the form of grids. If too thick, of course the returns will be greater, though if too thin the blue and white do not separate so easily. Also the form of the casting is important, for it should be so cast that two pieces placed on top of one another should have as little contact as possible, as if the contact between two coatings is so much as to hinder the vapours penetrating between them, there is little or no corrosion.

Great care and attention also must be given in building the stacks. The boards covering each bed must not be laid close on to the lead, as in corroding the lead expands, and the boards, wet with the moisture coming into contact with the lead, will discolour it. On the other hand,

there must not be too much space left between the lead and the covering boards, or it will tend to lower the temperature, and the vapours, being less confined, will not act so readily. These and many other points of detail have to receive constant attention by the stack-lead maker, but the principle in all cases is the same, and with the exception of the details necessary for working on a large scale, practically identical with those of the old philosophers, who, centuries ago, made their production in a single pot.

(3) SOME RECENT IMPROVEMENTS.

It has already been mentioned that the pig lead from which the white lead is made must be fully refined, and that as little as 0·0005 per cent. silver constitutes an impurity sufficient to damage the colour of the finished white lead.

Lead imported into this country generally contains from 40 to 300 ozs. of silver to the ton. This silver has to be extracted, both for its own value and to prepare the lead for manufacturing purposes. Originally the silver was extracted by cupellation, which process consists in converting the whole of the lead into oxide and separating it from the silver which remains in the metallic state. This, however, entails a large amount of labour, and is only practicable when the amount of silver present is comparatively large. The modern method is either by the zinc process, the Pattinsonian process, or a combination of the two.

In the zinc process about 18 or 20 tons of the rich lead is melted and thoroughly stirred with about 1 to 2 per cent. of zinc. On standing, the zinc rises to the surface bringing with it the silver, forming a solid crust, which is removed and subsequently treated for silver.

Messrs. Foster, Blackett & Wilson of the Tyne-head works, adopt the Pattinsonian process, which enables them to produce a chemically pure lead.

The zinc process is quicker and perhaps more economical, but the refined lead is apt to contain traces of zinc, which is a most deleterious constituent, if the lead is to be used for chemical purposes.

The principle of the Pattinsonian process is that when lead containing silver is melted and cooled whilst being constantly stirred, that portion which solidifies first (in the form of crystals) contains very much less silver than that which remains molten. In working, there are a series of pots, into one of which a charge of rich lead is put. As the crystals of lead form, they are well drained in a perforated ladle and transferred into the adjoining pot, and the liquid argentiferous lead is ladled into the adjoining pot on the other side. This process is continued all through the series, and by the time the lead reaches the pot at the end, it has attained a very high degree of refinement. The rich argentiferous lead containing about 500 ozs. of silver to the ton, which finds its way to the extreme pot at the other end, is cast into pigs and the silver recovered by cupellation.

This is the method followed by Messrs. Foster, Blackett & Co., who succeed in refining the lead so as to contain only traces of silver. They have three series of pots, and turn out a large quantity of refined lead per week.

Fig. 1 shows the desilverising pots at the works, the workman draining a ladleful of lead crystals.

The usual procedure in casting and building the lead on the stack is as follows :—The pigs of metal are melted in a large pot from which women ladle it out and cast it into the form required; when it has cooled, others pile it into little heaps, and men and women carry these piles (weighing often 40 or 50 lbs.) on their heads and shoulders to the stack, and climb with them by means of a ladder to the bed being laid. This operation thus necessitates much manual labour of a tedious and dangerous kind.

Messrs. Locke, Lancaster and W. W. & R. Johnson at their white lead factories have adopted an ingenious arrangement which obviates all this labour. As seen from the photograph (Fig. 2), the molten lead runs from an orifice in the bottom of the pot on to a travelling endless band, consisting of a number of iron plates, upon which the lead casts itself into the requisite form of crate.

By regulating the flow of the molten

lead any desired thickness of casting may be obtained. The travelling band empties the castings on to an elevator, and the latter fills a truck, which after being weighed, is run along rails to the mouth of the stack, where it is placed into the pots. The small apparatus seen in the photograph is capable of casting three tons per hour, and is driven by a small electro motor. When the stack is taken down, it is usual for the workers to pick up the corrosions, which, being more or less crumbly, produce much noxious dust, and place them into trays, one tray full weighing as much as 1 cwt. These are then carried on the head or shoulder along planks, often high in the air, according to the bed being stripped, to the rolling chamber or washbecks, where the core of metallic blue lead is separated from the white lead. The liability to absorb lead from the dust created in filling and emptying the trays, and from contact, is obvious. At Messrs. Locke, Lancaster & Johnson's Millwall works, the lead is corroded inside the pots, and in taking up the corrosions the man does not touch the lead, but merely empties the pot into a tub, which holds about 25 cwts. When full, an overhead electrically-driven gantry crane takes this up and empties into the separating tank, where the white lead is detached and washed through sieves into the becks, and the blue lead washed clean and taken away to be recast.

Fig. 3 shows the crane emptying a tub of corrosions into the separating tank.

The white lead, having been levigated through stones, is then drawn by a vacuum pump into a receiver, and forced into filter presses by air under a pressure of 100 lbs. to the sq. in. This novel method of pneumatic pressing, which does away with all handling, is very efficient. The two presses seen in Fig. 4 can turn out 30 tons per day. The air-compressing and vacuum plant is automatic, and worked by electricity; in fact, the works are unique in being entirely lighted and worked by electric power.

The most dangerous part of white lead making is in the drying and packing of it. Up to quite recently, the universal method was to put the pulp lead into trays and place on racks in a stove. When dry, the trays were taken out, the dried lead tipped into casks, rammed, and headed up. In this operation much dust is created, and very few engaged in drying and packing lead by this means escape the dangerous effects of lead poisoning. The Home Office, in fact, consider the matter so serious that in October, 1898, a letter was issued on the subject and sent to all manufacturers of white lead.

After commenting on the prevalence of lead poisoning, the Secretary of State goes on to say: "From the information in the possession of the Home Office, it appears that the stoves ordinarily used in the old Dutch process of manufacturing and packing are the chief sources of danger, and the Secretary of State desires seriously to invite the consideration of manufacturers to the question whether these stoves ought not in all cases to be replaced by newer stoves of safer construction. The Secretary of State feels that the state of things now prevailing in English leadworks generally, is so serious that it cannot possibly be allowed to continue, especially in view of the evidence available, that by proper mechanical and structural arrangements and effectual precautions, lead poisoning can be prevented, or at least very materially diminished."

As a result of this, and the new Government regulation, that after January 1st, 1901, the old form of stove is to be abandoned, or efficient means, approved in each case by the Chief Inspector of Factories, be adopted to effectually prevent white lead from coming into contact with any worker, there have arisen more improvements in the packing and drying than in any other department of white lead manufacture. Manufacturers, therefore, being forced to improve their drying arrangements, many inventions for drying and packing white lead automatically are being introduced. Some of these are very ingenious and efficient.

In Sanderson's patent apparatus the drying takes place in a long chamber through which hot air is passed, the white lead to be dried being carried on an endless band in an opposite direction to the

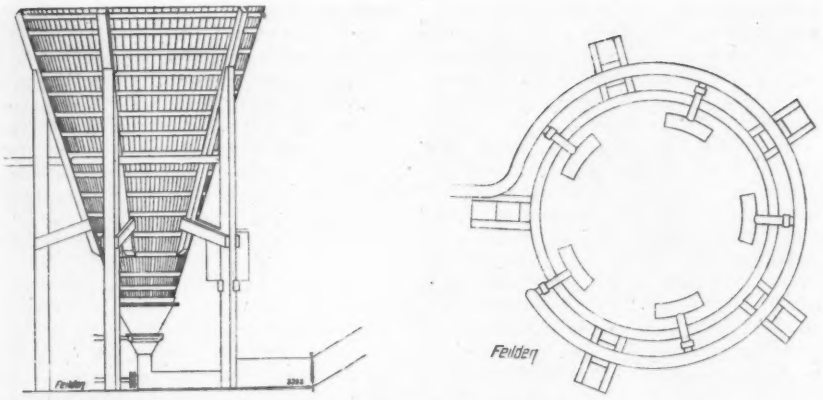


FIG. 11.—CONICAL VAT USED FOR SEPARATING THE PRECIPITATED WHITE LEAD AT THE THAMES WHITE LEAD WORKS.

air current. The drying property of the air is maintained while in the chamber by causing it to circulate over steam-heated radiating pipes, so that while it parts with its sensible heat in evaporating moisture from the substance which is being dried, it is constantly being re-heated.

In the case of wet white lead, the substance is thrown into a hopper above a pair of feed rolls which are contained within the drying chamber. The rolls are steam-heated by means of which the temperature of the substance is raised to about 212 degrees, so as to prevent moisture depositing upon it when it enters the somewhat moist atmosphere at that end of the chamber. The heating of the rolls also serves another very important purpose. If cold the substance adheres, so as to require a scraper for its removal, and accumulates in lumps on the scraper before falling; while when the hot roll is used, steam is generated between the film of white lead and the surface of the roll, and causes it to blister off and fall in flakes upon the band.

The motion of the band through the chamber is so slow and even that the lead is not disturbed in any way, and consequently no dust whatever is created to be carried off with the effluent air.

The lead is discharged into a hopper from which it is conveyed directly to a machine similar to those used for packing flour into barrels, and thus the dry material is never seen or handled until the cask requires to be headed up.

The illustrations show the construction of the apparatus :—

Fig. 5 is a longitudinal elevation with one side removed to show the interior.

Fig. 6 represents a plan with cover removed.

Fig. 7 represents a transverse sectional elevation.

The material is charged into the apparatus at *X*, and is discharged into the hopper at *D*, while the hot air enters at A^1 and escapes at A^2 to a shaft.

Another very excellent drying arrangement is that patented by Messrs. Locke, Lancaster & Johnson. This machine consists of circular iron tables mounted on a central column, the whole of which are revolved by means of suitable gearing. These are enclosed in a circular casing, in which doors are placed for charging the machine, and openings for the admission of the hot air; and on the opposite side of the casing is a square pocket, the full height of the machine. This acts as the uptake, and the dry white lead is also discharged into this by means of scrapers, and falls into barrels placed at the bottom. The air is heated in a patent stove, which effectually prevents any of the products of

combustion coming in contact with it, and ensures the purity of the lead. Dampers are provided for regulating the amount and temperature of the hot air in every way, so that the drying of the lead is perfectly under control.

In working, the fires are lighted, and the machine charged, and the hot air, which has been heated in the stoves to about 400° F., passed over the wet lead, when the moisture is evaporated and carried away. So long as there is any moisture in the lead, the temperature cannot exceed 212° F., and directly it rises above that, the fires may be drawn, as the operation is complete, and the lead will be found bone dry. The discharging is done by means of scrapers, which are let down on to the tables, and the lead falls into a barrel and is headed up.

The arrangement shown in the sketch (Fig. 8) is drying over 45 tons per week.

Amongst the different appliances now being provided for the comfort and safety of the workmen, the most recent addition is the "Sturtevant" dust-collecting plant (Fig. 9), which Messrs. Foster, Blackett & Wilson have erected for the purpose of preventing dust from rising during the process of packing dry white lead.

The installation consists of several sheet-iron hoods of special design connected by suitable piping with a powerful exhausting fan; the casks to be filled are placed near these hoods, and any dust arising during the operation is drawn away from the workmen by the fan and passes through a patent quencher, where it meets a spray and falls with the water into a collecting tank. By this system the danger hitherto associated with this part of the process has been effectually removed; and, further, the room in which the men work is now absolutely free from dust.

The two complete installations working in connection with white lead having proved so successful, similar plant is about to be erected in their red lead packing house.

One of the principal drawbacks to the stack process is the length of time taken in manufacture: the minimum time for the conversion of pig lead into white lead being 14 weeks. There have been many processes patented for the hastening of the manufacture, nearly all of which have come to an ignominious end, chiefly through ignorance and want of capital. Chemically, however, precipitation is undoubtedly the correct and most scientific method, and is without doubt the process of the future. At present there are only two or three companies in England employed in successfully manufacturing white lead by precipitation, but they have all met with a degree of success which speaks well for their future prosperity and development. Of these, Messrs. Brandrams, of Rotherhithe, are well known in the trade for turning out a white lead which for purity of colour is unsurpassed. The others who manufacture by precipitation have their own peculiar patents, of which

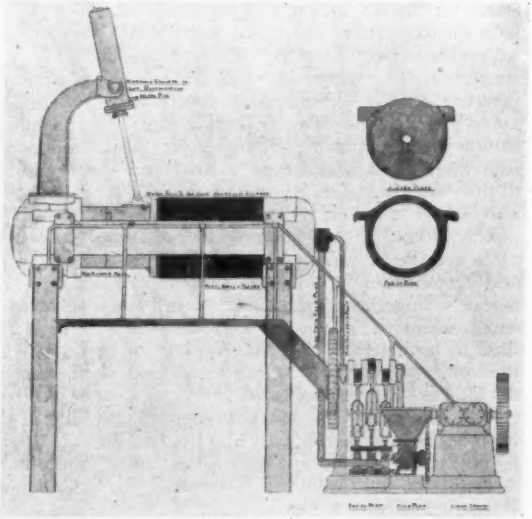


FIG. 12.—SOUTHBY'S PATENT HYDRAULIC PRESS.

FIG. 13.—CARBONATORS USED FOR PRECIPITATING WHITE LEAD BY THE THAMES WHITE LEAD CO., LTD., EAST GREENWICH.

the most interesting is perhaps that known as Sanderson's process.

This process is one in which the white lead is produced by precipitation by means of carbonic acid gas acting on a basic lead acetate solution.

Hitherto such precipitations have been extremely light, but by this process that objection is overcome and a very dense white lead is produced.

The method further enables this compound to be produced with any desired proportion of carbonate and hydrate, which is an advantage over the "stack" process, where there is no control in this direction.

It is simple to operate, and the conversion of pig lead into white is carried out in twenty-four hours. A weak solution of normal acetate of lead is converted into a tri-basic acetate solution by dissolving it in a further quantity of lead oxide. It is then treated with carbonic acid gas in carbonators (as shown in Fig. 13), which precipitates white lead and reduces the basic acetate again to a normal acetate, which is then used over again to dissolve more lead oxide, and the process is continuously carried out in the same cycle.

After the white lead is produced, it is usual to separate it by means of a filter press from the super-natant normal acetate liquor, to wash the precipitations, to free it from remaining liquor, and to dry it before mixing it with oil to form paint.

By means of another patent process these operations are eliminated, and the white lead already mixed with oil is produced without previous drying, and the most unhealthy part of the manufacture—viz., the drying and handling of the dry stuff and subsequent mixing of it in oil—is avoided.

The object of the conical settler shown in the illustration is to save filter pressing after carbonating; the clarified mother liquor (normal lead acetate) flows away at the top, while the deposited white lead

precipitate is run from the bottom into pugs, where it is treated with an excess of oil which, combining with the white lead, displaces the adhering acetate solution. The *excess* of oil, together with any remaining trace of moisture, is then pressed out by means of an ingenious hydraulic press, patented by Mr. A. G. Southby. This press can be adapted for pressing fats or other substances requiring a high and steady pressure. That shown in Fig. 12 was specially erected for working Sanderson's process.

Thus, from the recent improvements that have been here briefly described, it will be seen that the advancement of this most important and interesting industry is at last, after many centuries, taking place, with the improvements all tending in the right direction in minimising the danger to the operatives, and placing the manufacture upon sound and scientific principles.

L. M. G. Cuthbertson

Electrical Fires.

By WILLIAM BREW, A.INST.E.E

MR. WM. BREW has had a varied practical experience of mechanical and electrical engineering extending over fifteen years, and comprising traction work, electric lighting, etc. He was elected an Associate of the Institute of Electrical Engineers in 1890, and has taken part in the installation and subsequent management of some important Provincial and London lighting stations.

Mr. Brew is Lecturer to the Battersea Polytechnic on the subject of electric lighting, and has for some years been engaged in electrical consulting work.

DURING the period 1896–8 the number of fires in the County of London were at the rate of about 3,570 per annum; of this huge number, candles, oil, and spirit lamps were accounted responsible for over 18 per cent., gas about 8 per cent., whilst the number of fires directly traced to the employment of the electric light amounted to the modest figure of 0·2 per cent. only. It may be as well to point out, however, that the number of cases of unknown cause of fire amounted to over 28 per cent. during the same period, and there are possibly a certain number of electrical fires included in the 28 per cent.; on the other hand, this percentage of cases of unknown cause of fire is slightly below its average for the last 30 years, and it would therefore appear that the introduction of the electric light has not added much at all events to the mystery of the unknown causes in this respect. That the electric light is by far the safest illuminant probably few will deny, and the Metropolitan Fire Brigade Reports speak for themselves; but from the number of rules and regulations appertaining to electric light installations issued by the insurance companies, the electric supply companies, and others, on behalf of the consumer, the latter can hardly be blamed if he sometimes regards the electric light as positively dangerous.

The various sets of rules are of course drawn up to guard the different interests of those who issue them, but at the present time it is not always self-evident what fault a particular rule is intended to eliminate, and it may be of interest to review some of the rules and the nature of the faults they are intended to deal with, which, if fully grasped by the wireman, should prove a greater safeguard, in the writer's opinion, than so many of the rules upon the evasion of which his ingenuity is frequently exercised at present.

FUSES.

One of the points upon which we find great diversity of opinion is that of fuses, not only as regards the material of which they should be composed, but also as to the length of break required, their position, etc. For instance, in one set of rules one finds copper fuses specified, in another case tin fuses only are to be employed, whilst in a third both copper and tin fuses are allowed.

With regard to the material of which a fuse should be constructed, it is important to notice that the various metals and alloys have decided characteristics when employed for this purpose, and it may be

of advantage to examine briefly the phenomena of the blowing of a fuse and the arc it produces.

Consider first the case of a 10-ampère arc lamp with a normal P.D. of 45 volts across the arc together with that of a 100-ampère search light; the P.D. across the arc of the latter will not be so very much greater than that with the 10-ampère lamp, say, 60 volts normal; then the apparent resistance of the 10-ampère arc is $\frac{45}{10} = 4{\cdot}5$ ohms, whilst that of the 100-ampère arc is only $\frac{60}{100} = 0{\cdot}6$ ohms. This decided diminution in the resistance of the arc in the latter case is mainly accounted for by the much increased effective sectional area of the 100-ampère arc and the greater surface of carbon over which volatilisation is taking place, and the consequent feeding of the arc with a greater amount of conducting gas and particles of carbon. In fact, the resistance in use with arc lamps on constant potential circuits is nearly altogether responsible for the current which flows and the size of the arc obtained, and without the resistance the arc creeping over the surface of the carbons attains large dimensions and the current becomes very heavy.

Now it is well known that with normal arcs formed between carbon and metal points, the P.D. required across these points is greater as the length of the arc is increased, and diminishes as the current increases; with metal arcs also the size of the electrodes seems to play an important part, and in the writer's experience the laws obtained so far are with difficulty, if at all, applicable in predicting the length of arc we may get formed at fuse terminals when a short circuit occurs. In the general case of a fuse being blown by a short circuit we may have practically the full P.D. of the supply across the fuse terminals, and in addition a current which is only limited in amount by the resistance of the conductors up to the point, which, of course, may be, and usually is, extremely small; moreover, the length of arc which can be maintained in such cases with any given pressure of supply seems to depend very largely upon this short circuit current and the extent of the metal surfaces over which volatilisation can go on, and where a fuse between a branch circuit and a heavy main would act perfectly if the short circuit occurred on the branch at some distance from the main, the former, although of comparatively small resistance, reducing the pressure across the fuse terminals with the heavy short circuit current, yet with a short circuit close to the main, such as at the back of a distribution board, the arc at the fuse terminals is much more vicious, and porcelains, etc., forming fuse bases, invariably suffer more.

The writer has been in central stations when the fuses between the feeders and the bus bars have blown in quick succession, leaving the last fuse to go with practically the whole of the outgoing current to break; in one case where the pressure at the station was 120 volts, and the outgoing current about 1,000 ampères, the arc formed at the blowing of the last fuse flared away over a distance exceeding two inches, completely destroying the brass work and terminals before the arc could be distinguished. The arc in this case was fed by metal particles, and vapour rapidly set free over a considerable area of the brass terminals permitting the arc to be maintained over this abnormal length with the pressure quoted; but all metals, and particularly some alloys when volatilised by the arc, do not show the same power of maintaining it over a given distance under the same working conditions, the metallic vapour in some cases appearing to be less conducting than in others, and to present less favourable conditions for the maintenance of the arc.

Some typical characteristics of a few materials when used in the construction of fuses are shown in the photographs, they refer to 5 amp. and 10 amp. fuses, and were all blown under identical conditions as regards voltage and short circuiting.

Taking first the case of a tin fuse, photographs almost invariably show a displacement of the arc at the instant of volatilisation; in Fig. 1, which is a photograph of a 5-amp. tin fuse, the original position of the fuse can be seen passing straight between the clamping terminals together with the displaced arc, which

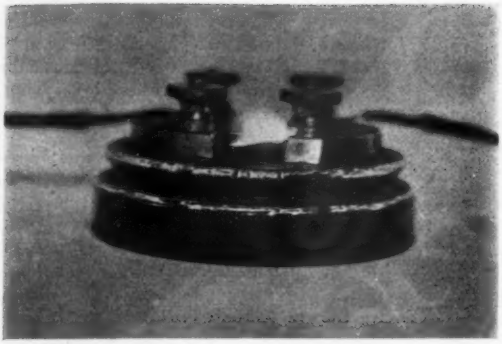


FIG. 1.—EFFECT OF 5-AMPÈRE TIN FUSE BLOWING.

may strike any live metal in its neighbourhood, and is a strong argument for the rules against the employment of double-pole fuses fitted under the same cover, in which cases disastrous arcs may be established between the + and − wires, and readily cause a fire.

In Fig. 2, which is a photograph of a 10-amp. tin fuse, the displacement of the arc is such as to have the appearance of lying upon the surface of the fuse base between the metal terminals; this is really incandescent tin vapour which has bridged across the fuse terminals, and the whole is typical of the arc so destructive to porcelain, etc., bases, and is such that it can be maintained over a considerable distance if the short circuit occurs on its branch near the main, as already explained.

Figs. 3 and 4 are photographs of 5-amp. and 10-amp. copper fuses respectively, and it should be noticed that in this case, although the arc completely bridges the terminals, the disruption of the wire, though complete, is unaccompanied by the displacement observed in the case of tin.

Figs. 5 and 7 are photographs of 5-amp. and 10-amp. fuses respectively, made of platinoid, an alloy of copper, nickel, and zinc, together with a little tungsten; and it is interesting to note that in this case the arc never reaches completely across the terminals, as in the two former cases, when tin and copper were employed.

It will, of course, be understood that if the distance between the terminals had been greater, or the electrical pressure of the supply less, the same result could have been obtained with tin or copper, but we are now comparing the behaviour of these metals under identical conditions of length of break, press, and current, and it must be borne in mind that one of the difficulties of the manufacturer of fittings is to get a sufficient length of break between his fuse terminals under a cover which shall not appear unsightly now that pressures of 200 volts and over are becoming the general thing.

It might also be thought that this effect was produced by the cooling of the ends of the platinoid by the metal terminals, but it must be remembered that the conductivity for heat of platinoid is less than either that of copper or tin, and the effect appears rather to be due to the fact that platinoid vapour, together with that of other alloys, possess little power of maintaining or feeding the arc, and a peculiarity which might be also noted with some

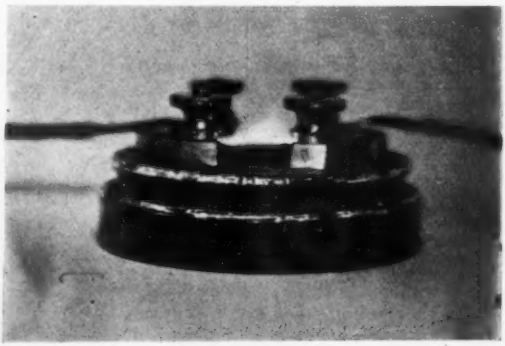


FIG. 2.—EFFECT OF 10-AMPÈRE TIN FUSE BLOWING.

alloy arcs is the presence of a nucleus or dark spot in the centre.

It will be seen that if the space between the fuse terminals is limited, then, as regards the breaking of the circuit merely, some alloy and copper fuses are superior to tin fuses, and, in addition, they possess greater mechanical strength and can be screwed up firmly under the fuse terminal, which is not so with tin fuses of small capacity on account of the ease with which this metal undergoes deformation.

There is, however, another important consideration, from a fire-risk point of view, in the choice of a metal with which to construct a fuse, and that is its working temperature, which depends upon the relation between the working current and the fusing current, usually fixed hard and fast by the rules of the fire insurance companies and others; but before reviewing these it may be of interest to examine briefly the relation between temperature and current for the three types of fuse made from tin, copper, and platinoid respectively, whose characteristics we have been discussing.

They are given in the following table :—

Table I.

Metal composing Fuse Wires.		Currents in Ampères.			
		Just warm to the touch.	Dull Red Hot.	Bright Red Hot.	Fused.
	S.W.G.				
Tin.	30	1·8	3·5	3·7	3·8
Copper.	40	2·1	3·9	4·1	4·8
Platinoid.	28	1·7	6·0	7·3	10·0

The point to notice is that although the currents required to just warm the fuse wires given above do not differ materially, they quickly diverge as the higher temperatures are reached, and if we examine the fusing currents, we find in the case of tin this is about 9 per cent. above that which will make the wire just dull red, whilst with copper it is about 23 per cent., and with platinoid the wire will not fuse until the current which will make it dull red hot has been exceeded by nearly 67 per cent.

It will be evident, therefore, that if the fuse is required to blow with a small increase of current above the normal, the copper fuse must be worked very hot, whilst the platinoid one would have to be constantly red hot, causing oxidation of the wire besides being a constant source of danger.

Now most sets of rules specify that the fuses must act at an increase of 50 per cent. above the normal working current, but in the case of arc lamps and motor circuits this margin is hardly large enough, whilst with certain arrangements of glow lamps it may be too great in order that the flexibles and smallest wires may be protected.

The smallest wire usually formed in installation work is the $\frac{3}{40}$ flexible, and although most insurance rules specify a larger wire than this, the $\frac{3}{40}$ still continues to be largely used.

Such a wire will carry 7 to 8 ampères without becoming more than just warm to the touch; now suppose an installation is arranged on the distributing board system with circuits of not more than 5 ampères each leaving the distributing board, it will be evident that if fuses are fitted to the board which will act with a 50 per cent. increase in the working current, each fuse in this case would go at $7\frac{1}{2}$ ampères and would protect every flexible on the circuit. A glance at the above table will show that tin fuses only could be employed on account of the high working temperature of the copper and platinoid fuses with this relation between working current and fusing current.

If, however, we distribute from the board, using only 3-ampère circuits and allow our fuses to blow at $2\frac{1}{2}$ times the working current, the flexibles would still be protected and copper fuses would be permissible since they would not be more than just warm with this working current.

Again, if the circuits leaving the distributing board were not of more than 2 ampères capacity and fuses were allowed which acted at, say, four times the working current, the flexibles would still be protected, and platinoid fuses could be employed without reaching an abnormally high working temperature.

It will be seen, therefore, that the relation between working current and fusing current is largely a matter for adjustment in any particular case, and from the writer's experience he is strongly of opinion that with the high voltages now in use a more suitable material for fuses than tin could be adopted with less damage to porcelain bases, etc., than at present. The breakage of porcelain bases and covers has been frequently ascribed to the expansion of the air at the time of the fuse blowing, and the writer has made numerous experiments on this point, using a rubber diaphragm to close an opening in an otherwise hermetically sealed fuse chamber, and the fitting shown in Fig. 6, which represents a very useful form of gland fuse box, he has employed in damp places and where service mains are taken into a building from an aerial main, the expansion of the air only becomes really perceptible when currents of 50 to 100 ampères at 100 to 200 volts are interrupted by the fuse; but with smaller currents he finds its effect to be practically nil, and the breaking of the porcelains should be rather ascribed to the type of arc described as resulting from the blowing of a 10-amp. tin fuse.

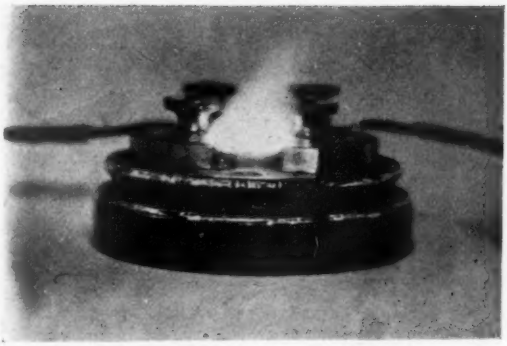


FIG. 3.—EFFECT OF 5-AMPÈRE COPPER FUSE BLOWING.

The curves of Fig. 10 refer to experiments made on a 200-volt circuit, the brake being horizontal between $\frac{1}{8}$ in. copper electrodes and accurately measured by means of a micrometer geared to one of the holders; the upper and lower curves have the same significance as in the case of the 110-volt circuit.

In fixing switches and fuses it must be distinctly understood that much longer arcs are obtained when the brake occurs vertically on account of the natural tendency of the heated vapours to rise upwards; moreover, the form of the arc may be practically a straight line between the contacts in this case, whereas with a horizontal break the arc becomes almost angular in its form, rising rapidly towards the centre and greatly increasing the length of path for a given distance between the contacts: this accounts for the bend at the lower portion of the curves.

FIG. 4.—EFFECT OF 10-AMPÈRE COPPER FUSE BLOWING

CONDUCTORS.

A glance at the numerous methods of running electric-light conductors advocated by various firms, each of whom claims its own to be absolutely the only safe one, will at least show there is some diversity of opinion upon this point, and it is a little confusing to an intending consumer, if he interests himself at all in the

FIG. 5.—EFFECT OF 5-AMPÈRE PLATINOID FUSE BLOWING.

matter, to find one building wired with both + and − conductors insulated and separated uniformly throughout their length by means of wood casing, another with both + and − conductors insulated and run as close together as possible inside a paper, lead, or steel tube, whilst in a third, wired on the concentric system, one of the conductors is placed in contact at several points along its length with earth.

The prevention of leakage of electricity from the conductors, with its accompanying risk of fire, is of primary importance in any system of wiring, and the various rules issued to avert such risks vary much in their requirements as regards insulation resistance, few of them taking any account of the working pressure of an installation and dealing only with the resistance to earth of the conductors, often ignoring also the insulation resistance between the wires themselves, which, in view of the fashion now to change from supply pressures of about 100 volts to sometimes 250 volts, is a state of things worthy of immediate consideration.

Suppose that in an installation the principal leakage occurred at a point between two wires, in a piece of damp casing for instance, the rate at which heat was being developed at this point would be $\frac{E^2}{R} \times 0{\cdot}24$ heat units per second, where E = difference of potential between the wires in volts, and R = the resistance in ohms of the path of leakage between the wires; it will be obvious that if we doubled the pressure of supply on such an installation, we should have four times the heat developed at the fault in a given time, and a building which would be just safe when coupled to 100-volt mains should hardly be passed also when a change to 250 volts was made in the pressure of supply, in which case the local heating would be increased by something over six-fold.

It cannot be too fully recognised by wiremen that leakage through damp wood such as often occurs in casing under roofs and floors causes a transfer of metallic salts by electrolysis and subsequently by diminishing the resistance of the leak a rapid carbonisation of the wood, which will fire unless the leak be remedied in time, and in some cases in the writer's ex-

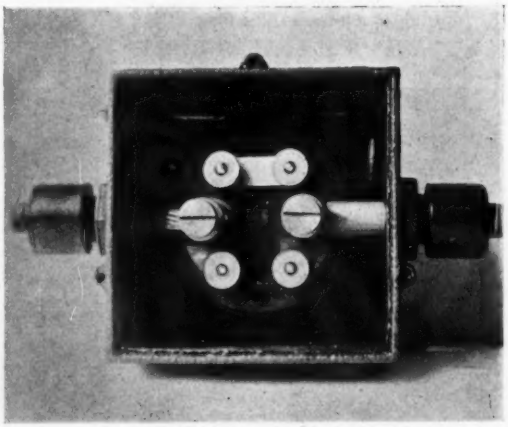


FIG. 6.—IMPROVED FORM OF GLAND FUSE BOX.

perience the + wire has become so reduced in section by electrolysis that it has been red hot at the fault with the normal current of the circuit passing.

One of the first considerations in a system of electrical conductors is that it should be a damp-proof one, not only when first erected, but throughout its life, in spite of the deteriorating influences of its surroundings.

We may consider some of the present methods of running conductors with reference to the following possibilities of fire risk from the conductors themselves, apart from other important questions, such as accessibility for examination and repairs :—

(*a*) Heating from leakage currents in damp situations,

FIG. 7.—EFFECT OF 10-AMPÈRE PLATINOID FUSE BLOWING.

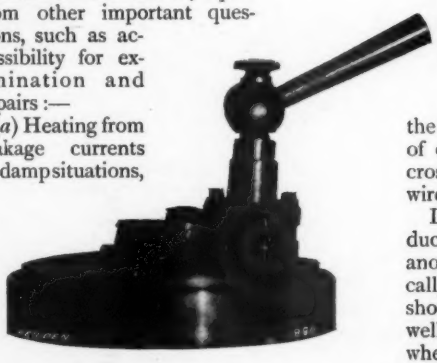


FIG. 8.—BRUSH TYPE OF SWITCH.

or consequent reduction of the conductors by electrolysis.

(*b*) Local heating from defective joints, or external mechanical injury to the conductors.

(*c*) Heating of the conductors from excessive currents due to defective fuses.

(*d*) Arcing between the conductors themselves or at breaks along their length due to external mechanical injury.

The use of wood casing for enclosing conductors is unsatisfactory as regards risk (*a*), on account of the difficulty of making it damp-proof; it is also defective as regards risks (*b*) and (*c*), since it is readily inflammable and offers little or no protection against nails and screws driven into the wall in which it is run. As regards risk (*d*), the conductors being rigidly separated, there is little danger of arcing between them, which forms, in fact, the chief merit of the casing system, except, of course, with faulty work at points of crossing and the injudicious bunching of wires in one groove.

In other systems we find the two conductors run as close as possible to one another, either side by side or concentrically, within a lead tube. We therefore should have a perfectly damp-proof and well-insulated system, and with most faults, when they occur, leakage will be confined to that between the near conductors, and be great enough to blow the fuse and so

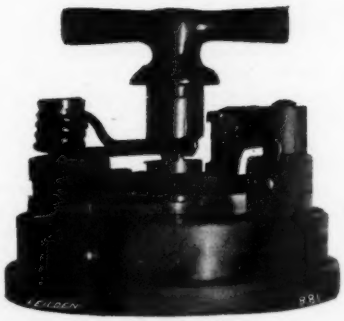


FIG. 9—DOUBLE-BRAKE SWITCH.

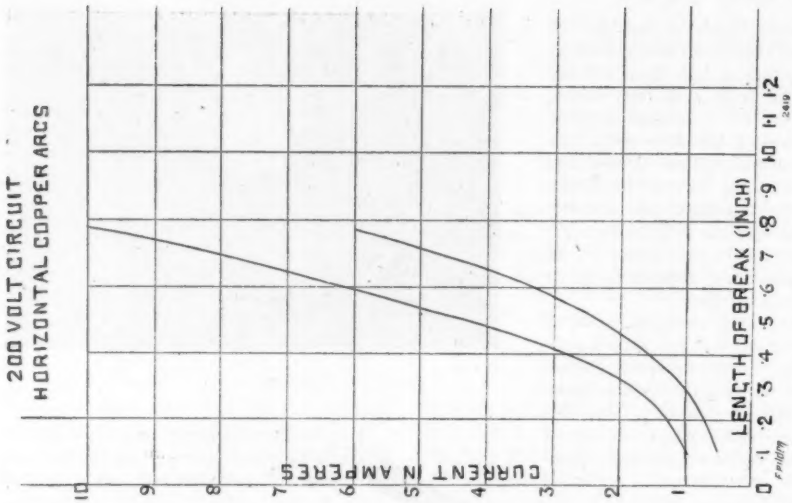


FIG. 10.

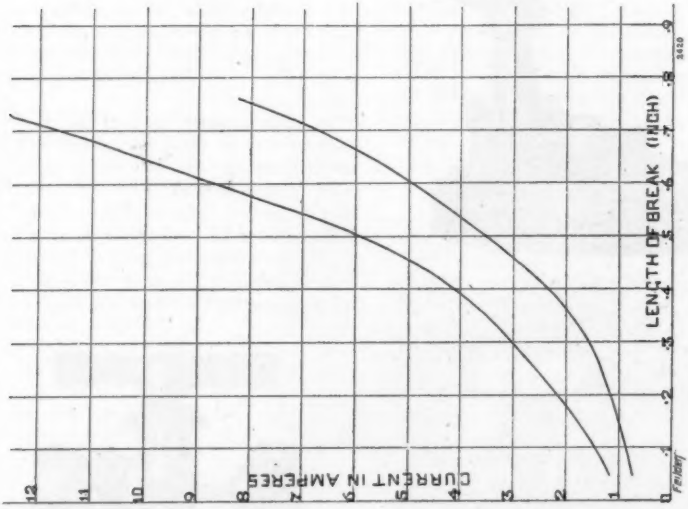


FIG. 11.

cut out the fault. The defect of these systems, as regards risks (*b*) and (*c*), is usually the insufficient mechanical protection against nails, etc., afforded by the lead covering, and where oil is used in conjunction with a paper dielectric it sometimes runs out into the distributing boxes, etc. As regards risk (*d*), in the writer's experience arcing has occurred between conductors so run, and has burned for some time without blowing the fuse.

In the armoured concentric and insulated conduit systems and others we have systems which are readily made damp proof, and have, in addition, the important merits of efficient mechanical

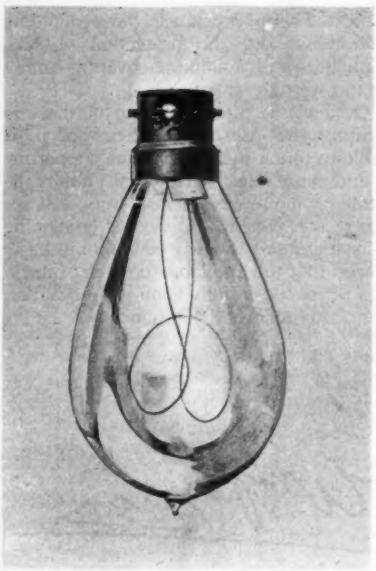


FIG. 12.

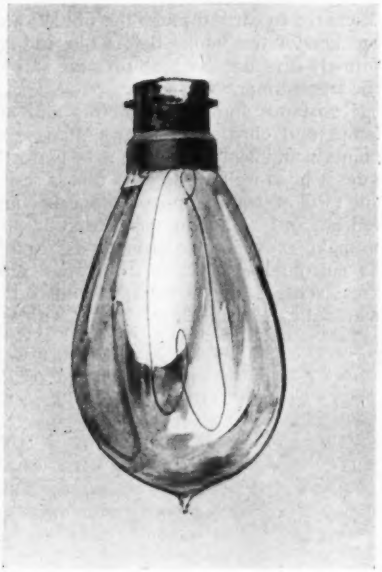


FIG. 13.

GLOW LAMP DESTROYED OWING TO HIGH-PRESSURE CURRENT DISCHARGING THROUGH HOLDERS TO EARTH.

protection, combined with the running of the conductors close together in a non-inflammable envelope, and since this envelope in the safety concentric system itself forms the return conductor and is connected to earth, we have complete immunity from risk (*a*) and little danger from risks (*b*), (*c*) and (*d*).

The writer is strongly of opinion that in the future this system, or a modification of it, in the form of an earthed conduit outer conductor from which the centre insulated conductor can be drawn for examination and repairs, will be largely adopted; the main objections to such systems at present being electrolytic troubles from difference of potential between distant houses so wired, when coupled to direct-current supply mains. This objection does not of course apply to private installation or to those supplied from an alternating- or continuous-current transformer.

In some few instances where conductors have to enter strong-rooms or ovens, or pass through fire-proof partitions, it is imperative that an absolutely non-inflammable dielectric be employed with the conductors; the writer has in such cases used iron wall tubes containing porcelain or slate distance pieces, through which bare conductors are threaded, the intervening spaces being filled up with sand or asbestos fibre.

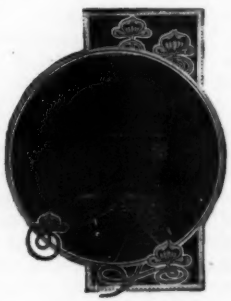
At present the use of electrostatic earthing devices on wiring supplied from the secondary of a high-pressure transformer can hardly be considered quite satisfactory on account of the sluggishness with which such devices act, and an earthed system of wiring has much to recommend it. Figs. 12 and 13 are photos of glow lamps taken from a building in which the insulation of the transformer supplying it broke down and allowed the high pressure of the primary winding to

discharge to earth through the holders and brackets of the lamps before blowing the primary fuse on the high-pressure side of the transformer.

Resistance frames for motors and arc lamps and choking coils are often weak points in an installation, and, to be perfectly safe, it is as well to assume that a resistance will at some time or other become red hot and a choking coil burn out, and to make provision accordingly as regards its surroundings. The writer has seen fires started by tarpaulins and other material carelessly left in contact with unprotected spiral resistances during building operations, and the protection of such appliances with a suitable covering cannot be too strongly urged.

On account of the sagging of the wire forming the resistance, when hot it is liable to touch the metal frame supporting it and cause leakage to earth unless the frame is mounted on insulators, and for this reason switches on circuits containing resistances and choking coils should be so placed that the appliance does not remain live when the switch is off—a precaution frequently ignored by wiremen.

(To be concluded in April issue.)



Electric Driving of Textile Factories.

By ERNEST KILBURN SCOTT, A.M.Inst.C.E.

OWING to the friction losses of line shafting, belts, etc., being practically constant, the overall efficiency of an ordinary mechanical transmission falls off very rapidly below full load. For instance, suppose the brake horse-power of a certain factory engine is 450, and that to run the shafting, etc., alone requires 150 b.h.p., then the efficiency of the system, that is $\frac{\text{b.h.p. delivered by shafting}}{\text{b.h.p. of engine}}$ will be about $\frac{300}{450} = 66$ per cent. at full load. When the engine is half loaded the efficiency will be $\frac{225 - 150}{225} = 33$ per cent., and at one-third load there is nothing left for useful work, all power being consumed in overcoming friction, etc.

Now, if we compare this with a well-laid-out electrical plant having, say, eight 50 b.h.p. motors, the full-load efficiency up to the motor spindles will be :—

$$\underset{92\%}{\text{Dynamo}} \times \underset{96\%}{\text{Line}} \times \underset{89\%}{\text{Motor}} = 79 \text{ per cent.}$$

And with engine half loaded :—

$$\underset{89\%}{\text{Dynamo}} \times \underset{98\%}{\text{Line}} \times \underset{84\%}{\text{Motor}} = 73 \text{ per cent.}$$

It will be noticed that as the load decreases the efficiency of the transmission line improves, and it would not be until about one-tenth of full load was reached that all power would be absorbed. A point to remember in this connection is that practically all the loss in mechanical transmission is frictional, and therefore destructive, in wearing out shafts, bearings, belts, ropes, etc. With electric transmission, on the other hand, only a very small proportion of the loss is frictional, the greater proportion being in the form of heat, which does no harm whatever. Another point is that, with electric driving, a sudden demand for extra power is instantly responded to by an additional supply of electric current from the main generator. For temporary overloads there is no comparison, electricity is so immensely superior.

In England all textile factories have their own steam-engine plant, but in America and on the Continent it is becoming quite a common practice to buy current from an electric power supply company. It happens that in the United States, Mr. W. B. Smith Whalley, of Columbia, has been in the fortunate position of being able to make a comparative test of a cotton-spinning mill supplied with electric power and a similar mill driven by a Corliss engine and ropes in the usual way. The electrically-driven factory had four 150-h.p. motors bolted to the ceiling of the various rooms. The test was made between April 1st and June 25th, 1897, and the results were given in a paper read at the New York meeting, December, 1897, of the American Society of Mechanical Engineers. The writer has tabulated the leading particulars in Table I., from which it will be seen that whereas the power required to drive the shafting, ropes, etc., of the steam mill was 226 h.p., the power required by the four motors of the electric mill, working under the same conditions, was only 149 h.p., which shows a saving of 77 h.p. in favour of electricity. The electric motors required no attention whatever (the oil in the bearings being only renewed once in six months, and then only as a precaution, not because it was necessary), whereas the steam engine and main shafting required the usual attendance and much oiling, the main driving ropes required sizing, etc.

Efficiency is an important matter, but it is only one of the many advantages which electric driving offers. For example, the turning moment on the spindle of an electric motor being constant, there is less wear

and tear, and superior work can be turned out, whilst the absence of vibration enables the motors to be bolted to the roof or wall or to machines direct.

The speeds at which they can be run and the ease with which the direction of rotation is reversed enables them to drive by gear-wheels, or if belting is used only a minimum amount is required (crossed belts not being necessary); there is thus loaded and unloaded; thus indicating at once the care with which the machinery is maintained, and the suitability of its construction for the work in hand.

One peculiarity which differentiates the electric motor from any other method of driving is that it automatically takes energy in proportion to the load put upon it. It is also essentially a high-speed piece of apparatus, and can therefore operate

TABLE I.

	Steam Driven.	Electrically Driven.
Method of driving	Corliss engine built 1895, cross compound, 800 h.p., cylinders 20 ins. and 40 ins. × 60 ins. Rope wheel 24 ft. diam. for 26 1¾-in. ropes, weight 35 tons.	Four 150-h.p. motors bolted to ceiling in convenient locations for economical distribution of power. Motors belted to shafting, the electric current rented from central station supply, and measured through a watt-meter.
Total weight of shafting ...	62 tons	55 tons
Number of spindles at work during test	11,776	12,448
Number of looms in mill ...	720	500
Number of looms at work during test	682	356
Power required for all purposes	535 h.p.	418 h.p.
Power required to drive looms and shafting	340 h.p.	206 h.p.
Power required to drive shafting alone	226 h.p.	149 h.p.
Power for looms only	340 − 226 = 114 h.p.	206 − 149 = 57 h.p.
Horse power per loom ...	$\frac{114}{682} = 0{\cdot}168$ h.p.	$\frac{57}{356} = 0{\cdot}16$ h.p.
Power for spindles and preparatory machinery	535 − 340 = 195 h.p.	418 − 206 = 212 h.p.
Number of spindles with preparatory machinery per horse power	$\frac{11776}{195} = 57$	$\frac{12448}{212} = 60$

more head room, greater safety, less noise, better lighting, and greater cleanliness—features which, re-acting on the employees, cannot fail to improve the quality and quantity of the work turned out.

The possibility of running one room—say the finishing machinery—on special overtime work without the terrible waste of power required when the whole of a heavy system of shafting and belting has to be moved is a great advantage.

An interesting feature is that, by merely putting an ammeter in a motor circuit, it is possible to measure the power consumption when the motor is running machines at higher speeds than when they are driven by counter-shafting.

There can be no doubt that, by transmitting the power electrically, it is possible to exercise much greater freedom in designing and organising the modern factory. As there is no heavy line shafting or vibration troubles the walls and roof may be of lighter construction, and as belt holes between floors are entirely avoided there is a much lessened fire risk. In connection with this matter it may be mentioned that the electric motor may be entirely or semi enclosed, and thus can be operated harmlessly (particularly the

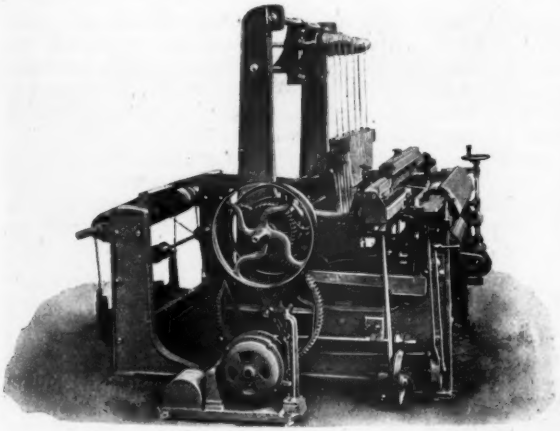


FIG. 1.—METHOD OF DRIVING LOOM BY MEANS OF THREE-PHASE ELECTRIC MOTOR.

multiphase type) in the presence of inflammable and even explosive material.

Perhaps one of the greatest advantages incidental to the introduction of electrical machinery into manufactories is the improved conditions for the employees. Not only is there ample light furnished at all hours—the same generator usually supplies light as well as power—but the absence of dust, dirt, and lint, which is being continually stirred up by belts, and the notable reduction in the noise of the factory, affords conditions which favourably affect both the quality and quantity of the output.

As the words "two-phase" and "three-phase" (*Drehstrom* in German), and the synonymous terms "multiphase" and "polyphase," are much used in connection with electric driving it would be perhaps as well to give a short explanation.

"Two-phase" and "three-phase" mean that the method of distributing the electric current is by means of alternating electric currents following each other rapidly through four wires and three wires respectively. When connected up to the stationary part—or the "stator," as it is called—of a two- or three-phase motor, these currents produce a rotating magnetic field which drags round with it the "rotor," or revolving part (a mass of laminated iron with copper conductors embedded in slots in its periphery), the spindle of which carries a pulley or pinion.

Two- and three-phase working, especially the latter, is the most favoured on the Continent, whereas in England most of the work up to now has been done on the continuous or direct-current system. It would take too long to give a complete comparison of the two systems of working, but it may be mentioned that in the driving of factories the multiphase motor has the advantage over the direct-current motor in that it has no commutator, and is therefore much simpler to construct and easier to look after when at work. Another advantage is that so long as the main generators are kept running at constant speed—that is, so long as the frequency of the alternating current remains constant—then, no matter how many or how large the motors are, the taking off or putting on of any one motor has no effect whatever on the speed of any others which may be running. With the continuous-current system the taking off of a motor raises the voltage on all the others on the same circuit, with the result that their speed is increased and adjustment must be made. This matter is more important than many may think, because the actual power taken to drive certain textile machines depends a good deal on the state of the atmosphere. Mavor & Coulson, of Glasgow, for example, installed an 80-h.p. motor in a woollen mill to drive twelve twisting frames (2,700 pendant, speed 2,000 to 4,400 revolutions per minute), five filling machines, and seven reels, and they found that the horse-power required was largely influenced by the state of the atmosphere, even to the extent of 20 to 30 per cent.

Constancy of speed is most desirable in textile machinery, because any jar or

uneven motion is very liable to break the threads. In spinning machines particularly, an absolutely steady motion is essential. Take the Cap spinning machine, for example, which is used for very fine worsted and mohair threads, etc. It has 144 spindles, each running at about 3,000 revolutions per minute, and as the fabrics into which the threads are made are usually not fulled, an extremely fine thread of

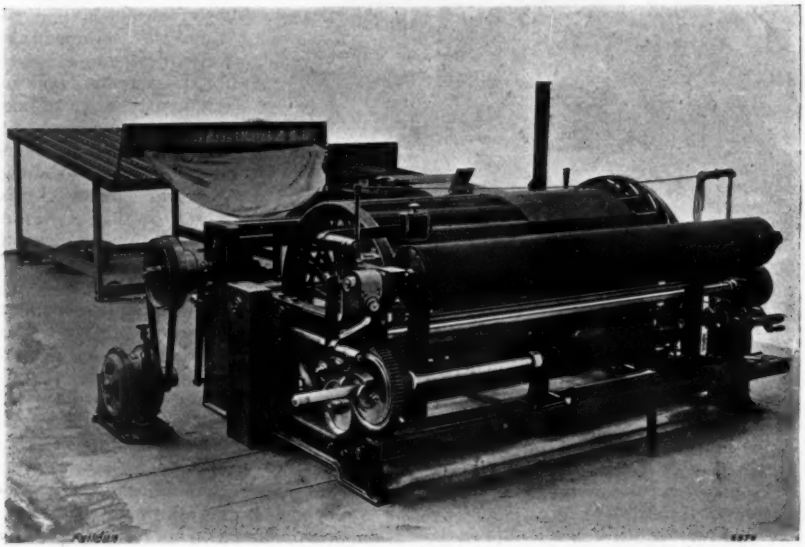


FIG. 2.—OERLIKON MOTOR DRIVING A SILK WARPING MACHINE.

absolutely even diameter is of the first importance. Here, then, is a case where the "constant speed" peculiarity of the multiphase motor may be utilised to great advantage. Again, practically the whole attention of the attendant on spinning machinery of various kinds is taken up in piecing the broken threads. A method of driving, therefore, which gives perfectly even turning should be beneficial.

In regulating the speed of a multiphase motor, resistances have to be used as in a continuous-current motor, but with this difference: that the resistances of the first-named are in the "induced" or quite separate rotor circuit, whereas in a continuous-current motor the resistances are right in the main circuit, and, generally speaking, more expensive to construct. Greater variation of speed can be obtained by inserting resistances in the circuit of a continuous-current motor, but for anything special—as, for example, the driving of a Callender, in which the speed variation is extremely wide—special arrangements must be made, whichever system of current distribution is employed. An objection that is frequently raised against the two- or three-phase motor is that when considerably overloaded it will pull up. It is just a question, however, whether this can be looked upon as an objectionable feature, because when continuous-current motors are laid down it is usual to protect them and the mains by inserting safety fuses and automatic circuit-breaking switches, so that when a certain current is exceeded the current shall be cut off. Given properly designed multiphase apparatus, automatic cut-off devices may be

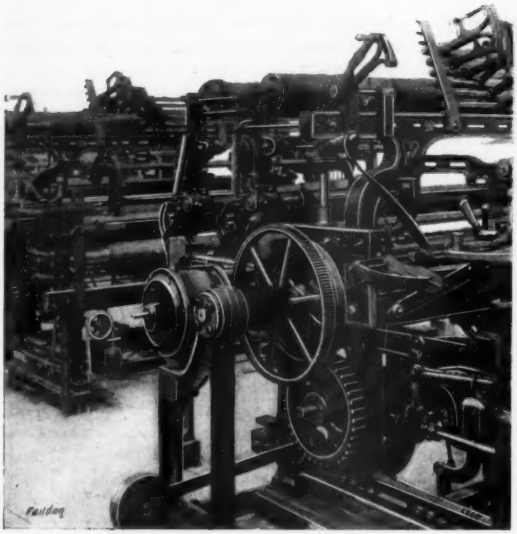


FIG. 3.—METHOD OF DRIVING LOOMS BY MEANS OF THREE-PHASE MOTOR.

dispensed with, and there is thus much less chance of an interruption and less attention is required.

The question of whether to group a number of machines together and drive by an electric motor, or whether to fix an individual motor on each machine, is a much debated question. Of course where electric power is applied to an existing mill the first method is cheaper, as it interferes least with existing arrangements.* In the case of a new mill, or an old mill which is being entirely refitted, the problem is different, and the ideal method of fixing a motor on each machine is frequently adopted. With such an arrangement it is possible to place the machines in any convenient position, quite irrespective of any line shafting, etc. Again, as the starting, stopping, etc., is effected by means of a switch, which may be placed in any position and at any distance from the motor, it is possible for the attendant to start or stop, without moving from the place he or she usually occupies when at work. For machines in which the setting of the work or the tuning occupies considerable time, the advantages of being able to shut off power completely from any one machine gives great saving of power. Individual driving, by banishing overhead shafting and belting, also tends to do away with the terrible scalping accidents which, however vigilant the factory inspectors may be, still occur where female labour is employed.

Some day it may be that the use of electricity may progress to such an extent that looms designed on the lines introduced by Mr. T. A. B. Carver will find a permanent place in our factories. For this loom of the Jacquard type 600 hooks are controlled electrically, and the pattern of the cloth is woven directly from a photo print mounted on a metallic sheet. The threads of the warp are picked up by electro-magnetic action, owing to the figures of the pattern being cut away, thus allowing the circuit to be completed by the metallic sheet. In actual looms which have been made the twill as well as the pattern is under complete management.

Figs. 1 to 4 show the method of driving by three-phase motors which has been adopted by the Oerlikon Works, Zurich. It will be seen that when the motor drives by a short belt it is hinged at one side, and the other end of the motor rides upon a spiral spring. The suspension is thus somewhat similar to that used on electric tramcar motors. In starting-up it enables the motor to give a little, thus reducing any jar on the mechanism, besides lessening the momentary current taken. Referring to Fig. 5, *A* is the motor, *B* the starting switch, and *C* and *D* the stator and rotor (of the motor) respectively.

It may be interesting to mention that

* In some cases the various processes of cloth manufacture are carried out by many small firms who are all located under one roof, and rent their power from the main mill engine. Naturally this system lends itself perfectly to electric driving, because it is possible to meter electric energy in the same way as gas or water, only with much greater accuracy.

many of the looms, etc., which are driven by electric motors in mills abroad have been made by British firms. Messrs. David Sowden & Sons, of Shipley, have looms under construction for the Continent at the present time which will be each driven by its own motor. They inform the writer that the special alteration required for electric driving can be made for a few shillings extra per loom.

Messrs. George Hodgson, Ltd., of Bradford, is another firm who has supplied looms, etc., for some time for driving by motors. For light silk looms and very high-class light articles, where it is absolutely detrimental to the fabrics to have a strain of any description from belting or shafting, they recommend the looms arranged in pairs and the motor placed between, driving one by an open belt and the other by a half-crossed belt, on to fast and loose or friction pulleys. This method has been adopted in many of the silk-weaving sheds in North Italy and in the Lyons district. In spinning-mills also it has been largely adopted, that is to say, one motor drives two frames.

For heavy looms, such as for carpets, tapestry and heavy coatings, the motors are usually coupled by means of spur gearing directly on to the crank shaft. This system has worked very successfully in several mills on the Continent, but there appears to be one drawback, viz., that when the loom knocks off, that is to say, when the weft breaks and the automatic stop motion is brought into gear, the high speed at which the motor runs has a tendency to make the loom bang against the stop rods or buffers, thus causing wear and tear in connection with the stop rod and frogs. In slow-running heavy looms, however, Messrs. G. Hodgson, Ltd., consider this system about the best method to employ.

In cotton looms, dress goods looms, and wherever ordinary articles are woven, as in the ordinary Bradford and Oldham trade, that is, in dress goods, light coatings, and cheap cotton goods, Oxford shirtings, etc., the motor will, in many cases, cost nearly as much as the machine it is going to drive, and the saving is small, as in weaving these classes of goods it is seldom a loom is standing. For such installations electric driving on to the end of each line of shafting is suitable.

Individual driving has been adopted in the Colmar Silk Weaving Factory, Germany; Messrs. Lorthois Brothers' Mills, Tourcoing, France; the Rüti Silk Weaving Factory, Zurich, Switzerland; Messrs. Egidio & Pio, Gavazzio Silk Mill, Desio, Italy; Herm, Schulk & Co., Silk Mill, Rovereto, South Tyrol, etc. One of the most notable examples of individual driving of looms is at St. Etienne, in France. This district has been famous for many years for its ribbon-weaving,

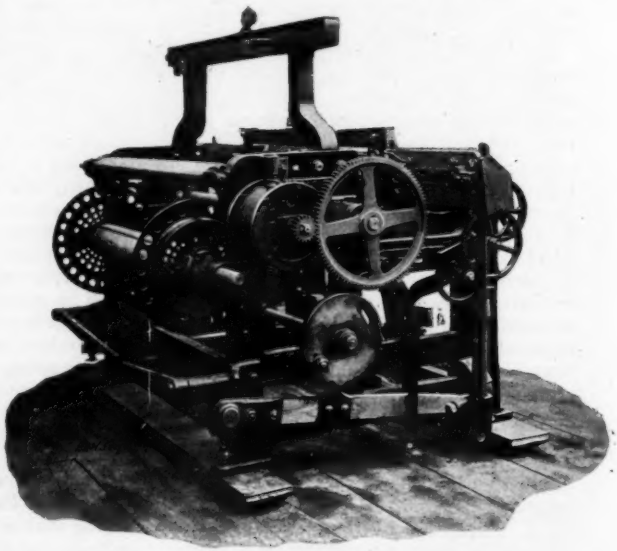


FIG. 4.—METHOD OF DRIVING LOOM BY MEANS OF THREE-PHASE MOTOR.

carried out upon hand looms, scattered about in houses and small workshops. Some few years ago, under the improved conditions in rival city factories, the score or so of towns and villages about St. Etienne began to languish, and it was only by the opportune establishment of a large public electric power supply by the Compagnie Electrique de la Loire that the danger was averted. This company supplies three-phase currents at 190 volts to over 2,500 ribbon looms, each one having its little ¼-h.p. motor. (The Oerlikon Company alone have supplied over 600 motors.) The charge for power is 10 frs. per month for each motor, and in order to encourage the use of electric power the company supplies the motors at a nominal rental; in many cases, however, the weavers buy their own. The total length of the transmission line is about 70 miles, with 36 transformer stations, from which both power and light are distributed.*

TABLE II.—LIST OF TEXTILE FACTORIES FITTED WITH ELECTRIC MOTORS.

Name of Firm.	Town.	Number of Motors Installed.	Generator.	
			Voltage.	Frequency.
Centenari & Zinelli, Tessuti Elastici	Milan	50	110	35
A. Flemmich's Söhne	Romerstadt	135	110	35
Ig. G. Zweig, Wien	Sternberg	180	110	35
Wilmer & Schönenberger	Gassau	123	110	35
Wm. Schroder & Co.	Egg	181	110	35
A. Brunner, Mech. Seidenstoffweberi	Mannedorf	133	110	35
R. Fasola	Como	80	110	35
Gourd & Co.	Faverges	62	110	35
Heer & Co.	Montluel	272	175	50
Mechanische Seidenstoffweberi ...	Rüti	540	190	50
Bardon & Ritton	Lyon	60	190	50
E. Scharer & Co.	Jona	72	190	50
Fabregos & Co....	Barcelona	120	190	50
G. Henneberg, Seidenstoffweberi, Rüti	Zurich	58	190	50
Camille, Brun & Co.	Firminy	50	190	50
Gessner & Co.	Wädensweil	200	190	50
Neeser, Weber & Digglemann ...	Zurich	21	190	50
Trebitsch & Söhne	Wien	280	190	50
Honegger & Co., Zurich	Wangen	100	190	50
L'Audibert & Co.	St. Pierre	80	190	50
Frey & Co.	Como	112	190	50
A. Caccia & Co.	"	85	190	50
Ig. G. Zeig, Wien	Wien	100	190	50
Aime Baboin	Lyon	50	190	50

On inquiring into what has been done on the Continent, a noticeable feature is the very large number of mills in Italy which have been equipped with electric power. In Como alone the following silk mills are provided with three-phase motors for independent driving of silk looms ($\frac{1}{10}$- to ½-h.p. each) and group-driving of the preparing machinery: Chiesa Bros., Luigi Brenin, Luigi Taroni, Camozza Melzi & Rosasco, Bosisio Camamia & Cattaneo, Carlo Casnati Basilio, and Masciardi & Maioratti. In many instances in North Italy and elsewhere the situation in which the mill is built is fixed upon with a view to utilising the power of some mountain stream. A canal is cut or a pipe-line laid down from the stream and storage provided by means of a large reservoir, near which the power-house is built. If the fall is low and the quantity of water relatively great, then turbines are installed, frequently with a vertical shaft, and the dynamo machine of what is known as the "umbrella" type. With a high fall, Pelton wheels are employed the alternators having horizontal shafts and being coupled direct, as for a steam engine. The electric power is transmitted over a pole line, carrying bare copper wires, to the mill and outbuildings and the cottages and stores of the workpeople, which, as a rule, are built by the proprietor of the mill. As the power costs practically nothing, the workpeople get the benefit of electric light, and sometimes electric heating, in their houses; and in case communication is bad, an electric light railway is

* Mr. T. G. Zweig, of Vienna, had an electric installation for distribution of light and power placed in his silk-weaving works in 1895, and it has been recently extended. He says of the electric motors: "The construction and the erection is without reproach. I have learnt by experience that the individual control of electric motors is very economical, and that the working of the looms is more regular than in the case of mechanical transmission." Messrs. Heer & Co., of Montluel, who, it will be noticed from Table II., have no less than 272 motors installed, say that the mean consumption of energy has been superior to their expectations, and, in consideration of the many advantages, they would not care to exchange the present electric-power installation for one with ordinary mechanical transmission.

laid down to the nearest railway or canal port.

In many instances the mills obtain the necessary current from some central electric power supply station. The Societa per la Filatura dei Cascami de Seta, at Vigevano, Italy, for example, is a case of a power station laid down primarily to drive several factories, but which also provides current for lighting the town and district of Vigevano. The capacity of this station is 720 h.p.

On the river Ticino, at Vizzola, there is a very large electric power station, distributing current at 10,000 volts to the industrial towns of Gallarate, Legnano,

TABLE III.—LIST OF SOME TEXTILE FACTORIES ON THE CONTINENT FITTED WITH ELECTRIC POWER.

Country.	Name of Firm.	Place.	Capacity of power station in horse-power.	System.	Generators are driven by	Sizes of Motors in horse-power.	Method of Driving.
Germany	Cotton Spinning and Weaving Mills	Arlen, near Singen	450 h.p. 2 of 225 h.p. each	Two phase	Turbines	180 h.p., 100 h.p. and smaller sizes	
,,	Mechanical Weaving Works, Jourdain	Altrich, Alsace	350 h.p. 2 of 175 h.p. each	Three phase	Steam engines		Group driving of looms and preparing machinery
,,	F. & Th. Frey, Spinning and Weaving Mills	Guebwiller, Alsace	250 h.p.	Three phase			Group driving
,,	Silk Weaving Factory, Waiblingen	Logelbach, near Colmar		Three phase			Special method of driving looms by small motors
Austria	Worsted Spinning Mills	Vöslau	240 h.p.	Three phase			A number of motors driving countershafting
France	Motte Dewavrin, Spinning Mill	Tourcoing	1 of 325 h.p. 1 of 20 h.p.	Three phase	Ropes		Special method of driving spinning machinery
,,	Lorthois Bros., Weaving Mills	Tourcoing	1 of 120 h.p. 1 of 27 h.p.	Three phase	Belt		Independent driving of heavy damask looms by 1 h.p. motors
Italy	Bianchi Muggiani & Sutermeister	Intra	1050 h.p. 3 of 350 h.p. each	Three phase	Turbines		Large motors for driving main shafting
,,	Aucmann & Co., Cotton Spinning Mill	Pordenone	800 h.p. 3 of 140 h.p. each	Three phase and continuous	Turbines	Three continuous current motors of 125 h.p. each	
,,	Giovanni Rossi, Woollen Mills	Schio	180 h.p.	Three phase			Group driving
,,	Aut and Aud Ponti, Weaving Factory	Solbiate Clona	220 h.p.	Three phase		80 h.p., 30 h.p. and 6 h.p.	Group driving
,,	Egidio & Pio Gavazzi, Silk Mill	Desio	930 h.p. 2 of 250 h.p. each 1 of 430 h.p.	Two phase		Two 120 h.p. and about 300 small motors	Each of the 300 small motors drives its own silk loom
,,	Roncari & Co., Spinning Mill	Besozzo	175 h.p.	Three phase		One 140 h.p. motor	For driving main shaft
,,	Wild & Alegg, Spinning Mills	Turin	1330 h.p. 1 of 880 h.p. 1 of 450 h.p.	Three phase		300 h.p., 200 h.p., 150 h.p. & 50 h.p.	For driving the mills at Borgone and Bussoleno
,,	Gioachino Zopfi, Cotton Spinning and Weaving	Bergamo	300 h.p.	Three phase			A large number of motors for driving the spinning, weaving, and dyeing machinery.
,,	G. Margotto, Spinning Mills	Valdagno	320 h.p. 1 of 180 h.p. 1 of 150 h.p.	Three phase		Two 140 h.p.	Driving two spinning mills each by a 140 h.p. motor
,,	Manifattura Festi Rasini	Villa d'Ogna	560 h.p. 2 of 280 h.p.	Three phase		One of 230 h.p. One of 150 h.p.	Driving main shafts
,,	Frua Banfi & Co., Spinning Mills	Legnano	2200 h.p. Capacity of motors	Three phase		600 h.p., 500 h.p., 400 h.p., 330 h.p., 250 h.p. and 125 h.p.	Current is supplied by the Vizzola Electricity Station and transformed down from 10,000 to 500 volts
Russia	Prochoroff Sons, Spinning Mills	Moscow	2600 h.p. 2 of 1000 h.p. 1 of 1600 h.p.	Three phase	Steam engines		Motors for single and group driving of self-actors, ring-spinning frames, card machines, etc.
,,	Cloth Factory, Tschebwerikow	Porodeschtshe	300 h.p.	Three phase			A number of motors.

land Somma Lombardo, which lie within a radius of about 25 miles. This area is practically the Manchester district of Italy, and there can be no doubt that, with cheap electric power delivered at their doors, competition with us will become much keener. At Rheinfelden, in German Switzerland, there is a very large electric power station, which supplies power to the Cloth Print Works of Dr. A. Feer Ernst at Lorrach-Bromloch, also to Bleach works,

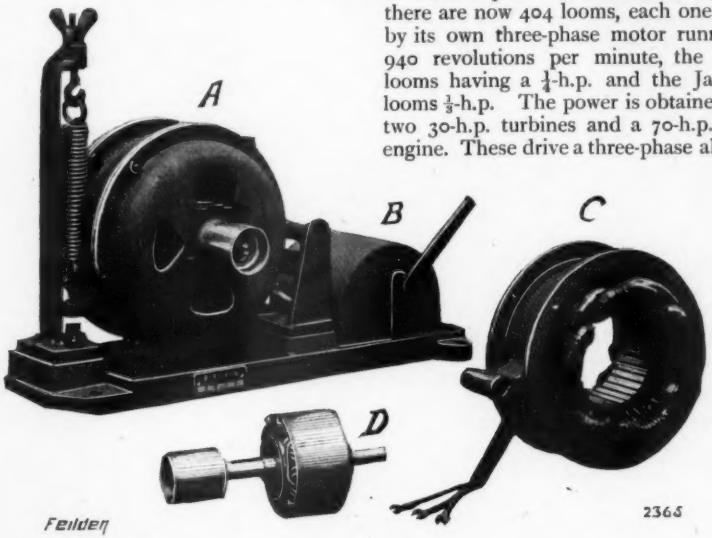


FIG. 5.—ELECTRIC MOTOR ADAPTED FOR DRIVING TEXTILE MACHINERY.

Carbide, and other factories, besides doing the lighting of the district. Although the Company only commenced to supply current in 1897, the full 16,800 h.p. is taken up, and another station is in hand to develop 10,000 h.p.

In France, the dyeing and finishing works of Gillet & Fils, at Villembaume, near Lyons, are driven entirely by three-phase motors both independently and grouped, supplied with current by the Société Lyonnaise de Forces Motrices du Rhone. This central power station is something after the same style as the one at Rheinfelden; its ultimate capacity will be 20,000 h.p., the machinery installed at the present time consisting of ten vertical shaft turbine generators, of 1,250 h.p. each.

Switzerland, the home of development of water-power by means of electricity, has many mills which are driven entirely by electric power. Prominent amongst them are the Rüti Silk Weaving Factory at Zurich and the Schaffhausen Worsted Mills. At the first-named the application of electric power dates back to 1895, and there are now 404 looms, each one driven by its own three-phase motor running at 940 revolutions per minute, the lighter looms having a ¼-h.p. and the Jacquard looms ⅓-h.p. The power is obtained from two 30-h.p. turbines and a 70-h.p. steam engine. These drive a three-phase alternating current generator, speed 500 revolutions, giving 200 volts at a periodicity of 50 for power; and a four-pole dynamo, running at 820 revolutions and giving 320 amps. at 125 volts, for lighting and also charging the accumulators. The main cables are carried along the roof of subways (high enough for a man to pass through them) built beneath the rooms and provided with transverse galleries at intervals. All of the conductors and fuses are placed in these galleries, and are therefore accessible for repairs. There are no wires or conductors in the rooms. In the weaving rooms the lighting is

effected by incandescent lamps with shades, the leads being brought to them through iron uprights with movable arms. In the other rooms inverted arc lamps are employed.*

At the Worsted Mills at Schaffhausen, there are 38,000 spindles, absorbing 600 b.h.p., and this is supplied by the Municipality from two 350-h.p. turbine dynamos giving continuous current at 700 volts. When the writer visited this mill last year, changes were being made in the driving. As now arranged, the machines and shafting are in groups driven by motors as follows :—One 120 h.p., one 100 h.p., six 60 h.p., two 30 h.p., and one 25 h.p.

Overhead wires for the transmission of electric power are quite common in Switzerland and in Italy, and it is the facility with which high-tension conductors have been allowed by the authorities which has assisted in the enormous development of electric power supply.

Curiously enough in the States the electric motor had found its way into almost every kind of manufactory before it was taken up by the textile industry. Once, however, that it got a footing, it carried all before it, and mills without electric light and power are quite the exception. The Columbia Cotton Mills, Pelzer, South Carolina, were amongst the first to adopt electric power. Early in 1894, when electric power was first thought of, the company had three mills, aggregating 52,000 spindles, and when the management saw that they could transmit electric power quite easily from a fall $2\frac{1}{2}$ miles away, they decided to build a fourth mill of 68,000 spindles capacity. At the present time the power-house has five pairs of horizontal wheels, working on a fall of 39 ft., and each pair is capable of developing 1,200 horse-power. The generators are of the standard three-phase type, as made by the General Electric Company of America, and each gives 750 kilo-watts at 3,600 volts. The transmission line from the power-house to the mills consists of eighteen bare copper wires, carried on porcelain insulators mounted on poles. Mill No. 3 is driven by a 450-h.p. electric motor connected to the main shaft by ropes. Mill No. 4 being comparatively new—it was started up in 1898—is equipped throughout by motors, distributed as follows :—

Basement.—One 50-h.p. motor, operating cloth-room machinery and elevators, and one 50-h.p. motor, operating pumps and heating apparatus.

First floor. — Four 75-h.p. motors, operating picker-room machinery, and four 130-h.p. motors, operating 1,580 looms on the first and second floors.

Second floor. — One 130-h.p. motor, operating 28 spinning frames.

Third floor. — Three 130-h.p. motors and two 30-h.p. motors, operating carding-room machinery.

Fourth floor.—Nine 130-h.p. and four 50-h.p. motors, operating spinning frames, warpers, and spoolers.

In addition, there are six small motors of 10-h.p. each, driving fans, pumps, and the mechanics' shop. Many of the motors, driving spinning machinery, etc., are attached to the ceilings of the rooms. (See Fig. 6.)

In the spinning and carding rooms, on account of the lint, etc., flying about, the "rotors" of the various motors are of the squirrel-cage type ; that is to say, the conductors are simply copper bars placed in tunnels in the revolving iron core, and short circuited at their ends, no brushes or other gear being required. All the other motors have "wound rotors;" that is to say, the conductors are wound up in coils, placed in the slots in the core, and connected to three slip-rings on the outer extremity of the shaft. Brushes press against these slip-rings, and are connected to resistances, which are thrown into circuit when the motor is started up.

In running these mills electrically it has been possible to observe accurately the difference in the amount of power required at varying temperatures of the atmosphere and conditions of moisture. Thus, in summer there is more than enough energy, but the middle of winter much more power is required, especially in the early

* In connection with the electric driving the company write :—"We are quite satisfied with the working of the electric installation put down at our works ; the working of the looms is silent and regular, and the repairs insignificant."

mornings. As the day advances the machinery, etc., warms up, and the conditions approximate to those of summer. This variation in power in winter has been found to be so great, that the company have found it economical, leaving out all questions of health and comfort, to always keep the mills well heated.

by the late Sir Titus Salt, at Saltaire, near Shipley, has tackled this question, and Messrs. Wright, of Loughborough, have adopted motor driving. Many bleach works have also taken it up.

The well-known Manningham Mills have a large electrical installation of 8,530 16-candle-power lamps, 40 enclosed arcs,

FIG. 6.—TWISTING FRAMES DRIVEN BY THREE-PHASE MOTORS.

Among other large cotton mills which have been electrically equipped (by Westinghouse) in the States may be mentioned the Grosvenor Dale Mills, Lyman Mills, an the Berlin Cotton Company's Mills. Besides electric motive-power there are 3,200 16-candle-power lights in the first-named, and in the second the total lighting and power load runs to over 2,200 h.p.

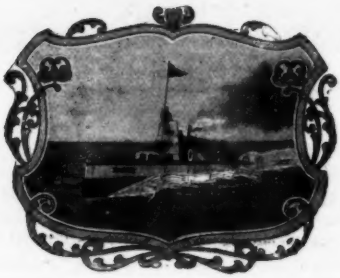
With regard to England, a certain amount of work is being done. For example, the old-established firm founded

and 25 motors ranging from $\frac{1}{2}$ to 30 h.p. each. The motors are used for operating machinery in the preparing, dyeing and finishing departments, also for working hoists, pumps and conveyors. The continuous current generating plant has a total capacity of 225 kilo-watts at 220 volts.

The British manufacturer is very conservative, and when he does install an electric motor equipment, is not, as a rule, anxious that others should know of it. A

few more years will, no doubt, bring great changes; as, by then, the various large electric-power supply companies will have got to work. Having their central stations conveniently situated for fuel, water, etc., and with the magnificent all-day loads which the driving of factories and work-shops, etc., gives, they will be able to sell electric energy at a rate which will compete most favourably with isolated steam plants. Only in this way can British industries be brought into line with what is being done abroad, for the development of water-power which is going on is enormous. We, unfortunately, have very little water-power, but we have excellent coal, which it behoves us to economise wherever we can. After all, although the water-power of our rivals is very cheap, and its use enables them to secure mechanical power by that beautifully simple (simple as compared with the steam engine) and even-turning apparatus, the turbine and Pelton wheel; yet, in our coal, we have this advantage, that we can be sure of a constant supply all the year round. With water-power there is always the possibility of shortage, due to a summer drought or to the small-feeding streams freezing up in winter.

In conclusion, the most sceptical, if he will but take the trouble to get at actual facts, must admit that the electric motor is the coming power for machine-driving. It has well earned its present position, having in most cases been adopted at first in a small way, and then been followed up cautiously as its advantages and reliability were demonstrated in actual work.



The Central London Railway.

By W. N. TWELVETREES, M.I.Mech.E

(*Continued from page 696, Vol. 3.*

❀ ❀ ❀

IMMEDIATELY adjoining the boiler house is the hall, in which are contained the main steam engines, electric generators and auxiliary apparatus of different kinds. A general idea of the arrangement of the machinery can be obtained by reference to the sketch-plan given in our December issue. At present there are six main engines and generators, space being provided for the addition of two other sets when required. The engines were supplied by The Edward P. Allis Co., of Milwaukee. They are of the Reynold-Corliss cross-compound condensing horizontal type, running at 94 revolutions per minute, and capable of developing 1,300 indicated h.p., as the most economical load, or 1,900 indicated h.p. if required. The main journals are 20 in. diameter by 36 in. long; the main shaft carries a fly-wheel weighing 100,000 lbs. and a 850 k.w. 3-phase generator, as shown in our illustration. The high and low pressure cylinders are of 24 in. and 46 in. diameter respectively, with a 48 in. stroke. Two eccentrics actuate the valve-gear of each cylinder; the gear includes automatic variable cut-off, and is controlled by a centrifugal governor of the ordinary type. Speed variations do not exceed 1·75 per cent. between minimum and maximum loads, and it was guaranteed by the makers that the steam consumption should not exceed 13½ lbs. per indicated horse-power per hour, when running with 26·5 in. vacuum, and indicating 1,000 h.p. Although the cylinders are protected externally by lagging, no use is made of the steam-jacket, whose advantages are well known to all engineers. This is somewhat surprising, as we are frequently told that nothing but the most advanced engineering practice is to be found in the United States. Speaking generally, it may be said that the engines appear to be well made and to be working satisfactorily, but we do not think any of our own engine-builders will be likely to accept them as models worthy of imitation, with regard either to design or to construction. In our December number a diagram was given showing the general arrangement of the steam pipes, by which it will be seen that each engine has its own supply pipe, capable of being connected directly with one boiler or indirectly with all the boilers. All these pipes, as well as those for atmospheric exhaust, injection and discharge, are below the floor of the engine-room. Before admission to the high-pressure cylinder, steam is passed through a separator, placed between the engine foundations, and during its subsequent passage to the low-pressure cylinder, the steam is dried in a multitubular heater, to which steam is admitted at boiler pressure. In order that any or all of the engines may be run non-condensing, a main atmospheric exhaust pipe is carried along the centre line of the building between the foundations of the engines. It is taken through the end wall, being carried up outside for a distance of about ten feet above the roof. The extremity of this pipe may be seen in Fig. 28, which gives a good idea of the exterior of the generating station. Each main engine is furnished with a combined jet-condenser and air-pump, capable of dealing with from 26,000 to 30,000 lbs. of steam per hour. The steam cylinder of this pump is 14 in. in diameter with a 24 in. stroke; the air-pump is double-acting, having a cylinder of 28 in. diameter, with a 24 in. stroke, and is capable of lifting the injection water from a depth of 20 feet, and of delivering it, together with the condensed steam, to the top of the cooling towers previousiy described, and illustrated in Fig. 26, *ante*, where it may be seen that the main in-

jection and discharge pipes are of 20 in. and 22 in. diameter respectively. Exhaust steam from the pump cylinder is discharged into the receiver of the main engine adjoining, whence it passes for use into the low-pressure cylinder. Steam from auxiliary plant generally is dealt with in a Wheeler surface-condenser having 1900 superficial feet of effective surface, and beneath this apparatus are placed the circulating and air-pumps. Circulation water is drawn from, and returned after cooling to, the tank beneath the cooling towers, but the discharge pipe from the air-pump communicates directly with the tank.

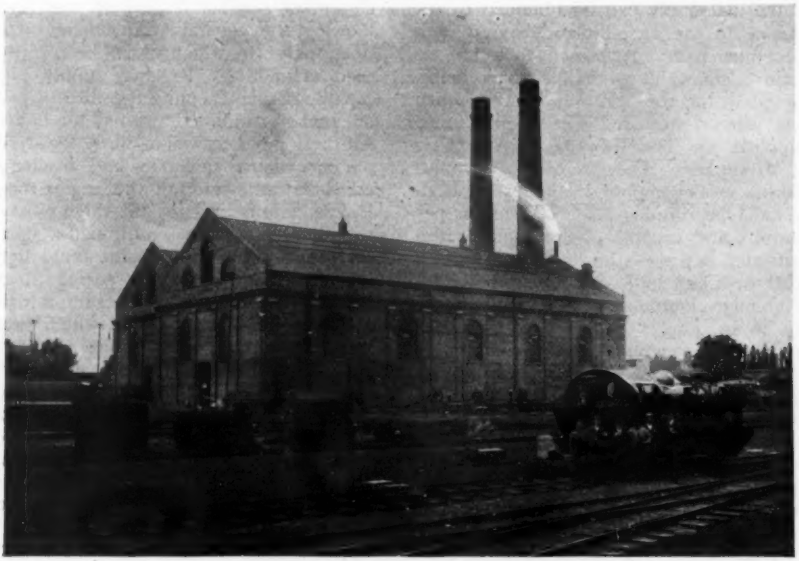


FIG. 28.—EXTERIOR OF GENERATING STATION, SHOWING YARD LOCOMOTIVE IN THE FOREGROUND.

Electric current is generated by three-phase alternators, 16 ft. diameter over all, with stationary armature and revolving field carried on the main shaft of each engine. One of these machines is shown in Fig. 29. Each alternator has 32 poles, and is capable of giving an output of 850 kilo-watts at 5,000 volts, with a frequency of 25 periods per second. The armature coils are suitably secured to the cast-iron outer ring, and the core is built up of laminated plates, grooved to form poles parallel to the axis of the machine. Measured in the same direction, the length of the core is 14·5 in., but spaces for ventilation and insulation reduce the net length to 10·8 in. There are 96 coils, three for each pole, laid in 192 slots cut across the armature core; thus it will be seen that there are two slots per phase per pole. By the arrangement adopted, inductance is minimised and heat losses are distributed over a greater radiating area than would be the case if a more concentrated system of winding had been adopted. The coils are formed of copper wire wound on formers, carefully insulated and held in position by wooden strips inserted in grooves near the slot openings. As indicated by dotted lines in the sectional drawing, the coil ends are cranked at different angles to permit them to clear one another, and as the armature can be

shifted laterally, away from the magnet wheel, the removal of any individual coil becomes a comparatively easy task.

The magnet wheel consists of a cast-iron hub and arms, having a cast-steel rim to which the 32 magnet cores are secured. The field coils are of strip copper, $1\frac{1}{2}$ in. by 0·8 in. thick, wound on edge on formers, and slipped over the cores. The

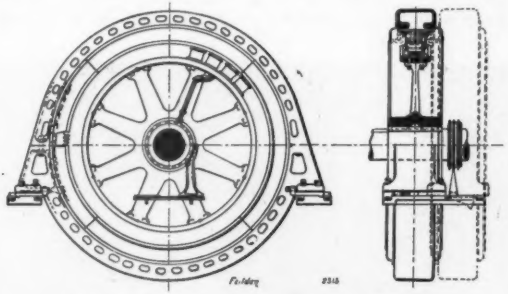


FIG. 29.—ELEVATION AND SECTION OF ALTERNATOR.

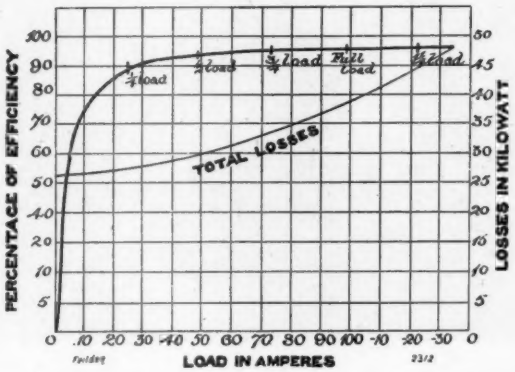


FIG. 30.—CURVE SHOWING EFFICIENCY AND TOTAL LOSSES OF ALTERNATOR.

exciting current is conveyed to the field at a pressure of 100 volts by two collector rings on the main shaft, each ring having two brushes. A curve showing the efficiency of one of the alternators at different loads, will be found in Fig. 30, where also a curve is given indicating the total losses.

Four exciter sets for the generators are situated near the north end of the engine-room. These are direct-driven by Allis compound engines, having $9\frac{1}{2}$-in. and 15-in. diameter cylinders, 6-in. stroke, and running at 400 revolutions per minute. The output for each set is 50 kilo-watts at 125 volts. It was stipulated by the consulting engineers that the excitation should be less than 16 kilo-watts, and we believe that as a matter of fact it is less than 14 kilo-watts. A view of the four sets will be found in Fig. 31, and in Fig. 32 are shown two engines and generators used for lighting the generating station and depôt. The latter machines are of the British Thomson-Houston direct current compound-wound type, having an output of 50 kilo-watts at 500—525 volts when running at 400 revolutions per

minute. These are directly driven by Belliss and Morcom two-crank compound double-acting quick-revolution engines, with forced lubrication. It is not likely that more than four of the main generators will be required for working the line, therefore two sets will always be ready for emergencies, and whenever necessary the remaining spaces in the power-house can be occupied by two more engines and alternators, so as to provide further power.

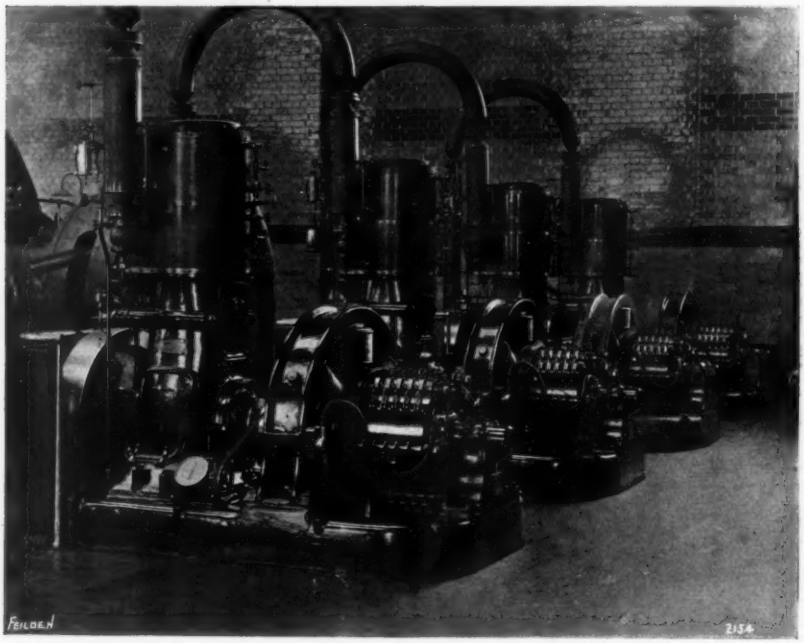


FIG. 31.—EXCITER SETS.

The main switch-board is situated at the north end of the engine building, and is erected on a spacious gallery.

So that the general scheme may be the better appreciated, we give in Fig. 33 a diagram of the electrical connections, which, it should be noted, includes only one of the generators and one exciter. Commencing at the left hand, four panels are assigned to the exciters, being furnished with ammeters, field rheostats, and voltmeter plug switches in the upper portion; and with double-pole 400-amp. switches, field switches, and minimum current cut-outs in the lower portion. Two Weston voltmeters with illuminated dials are mounted on a hinged bracket at the end of the board. Next in order come six main generator panels, the most interesting feature in which is the high-tension switch designed by Mr. H. F. Parshall, consulting electrical engineer to the railway company. A drawing of this switch is reproduced in Fig. 34, where it will be observed there are two blades, one on each side of the panel. The contacts are mounted on ebonite pillars, and, being also placed at opposite sides of the panel, it is impossible for an arc to occur between the positive and negative terminals. The switches are placed high on the board, and

are worked by wooden rods connected to the slotted bars, as seen in the figure. When the handle is first drawn down, the spiral spring is extended, and when the end of the slot engages the pin the switches are pulled out with a very quick break. Each generator panel is furnished with a voltmeter coupled to the secondary of a small single-phase transformer, reducing the generator pressure; two ammeters, connected in the secondaries of two bus-bar transformers, indicating the currents in two of the phases; also with an ammeter, shunted by a low resistance in the direct current exciting circuit; a voltmeter plug switch, and a lamp switch. On the lower part of the panel there are fittings similar to those on the exciter panels before described, and two voltmeters with illuminated dials, over which are synchronising lamps. There is also a red lamp on each panel, which is alight whenever the corresponding generator is excited. Coming next are two feeder panels, having three-phase switches similar to the generator switches, a bus-bar transformer ammeter; and on the lower portion of each panel a Holden indicating wattmeter, and a Thomson integrating wattmeter. Of the outgoing feeders, two are on the main switch-board and the other two are under the control of the oil-break switches placed beneath the gallery. The lighting board of four panels is at the extreme right-hand end of the gallery, and is fitted with all the requisite instruments.

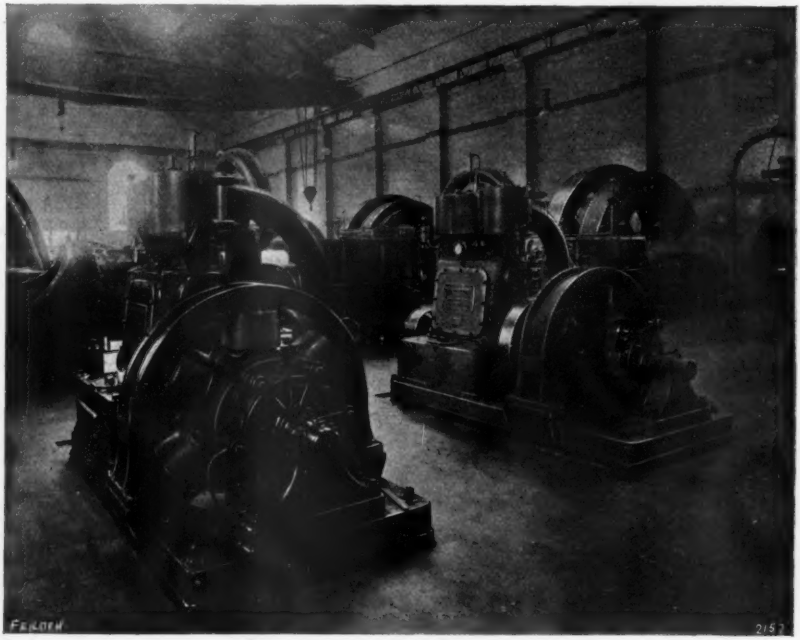


FIG. 32.—ENGINES AND GENERATORS USED FOR LIGHTING.

Before proceeding to inquire into the general system of power transmission, it will be convenient to deal with and dispose of the remaining portion of the establishment at Shepherd's Bush, and to give

a brief description of the locomotives and rolling stock.

The greater part of the depôt is occupied by sidings, which have a total length of metals quite equal to the distance traversed by the passenger line. In addition to sidings, the depôt includes an extensive range of sheds, one of six bays capable of accommodating 24 locomotives, another of twelve bays where 12 trains can be stabled, besides other sheds for engine repairs, carriage repairs, and carriage washing; but we believe that the latter are now to be used for

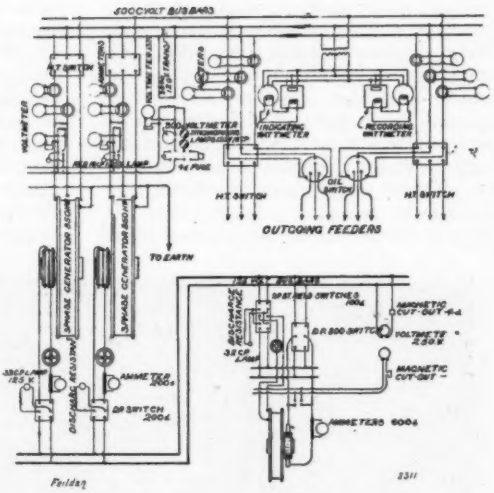


FIG. 33.—ELECTRICAL CONNECTIONS OF MAIN SWITCH-BOARD.

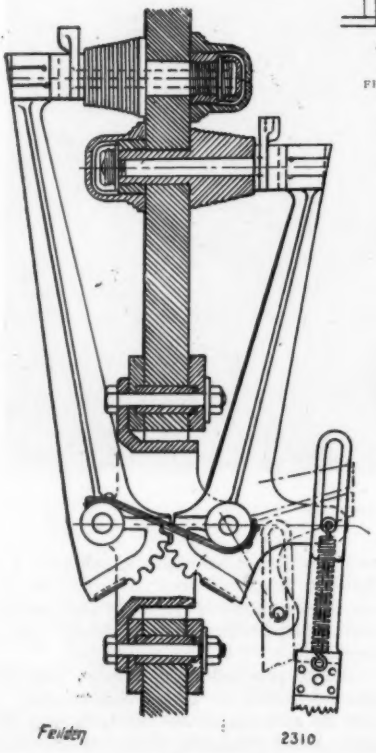


FIG. 34.—PARSHALL HIGH-TENSION SWITCH.

stabling, so that there is actually sufficient space to accommodate the whole rolling stock of the line at one time should such a contingency become necessary. It was the original intention that the tracks in the depôt should be furnished with third rails for the transmission of current to the locomotives, but this idea has very wisely been abandoned, and overhead wires are now installed, so that the system now resembles that adopted by the Thomson-Houston Company under very similar circumstances in Paris. Before the application of electricity, the only means of moving the engines and passenger coaches in the depôt, and of hauling them to and from the running tunnels, was furnished by two steam locomotives, one of which appears in Fig. 28. These are of the type known as tank locomotives, and they were built by the Hunslet Engine Company, of Leeds.

The photograph reproduced in Fig. 35 shows an interior view of the carriage sheds, and also gives an idea of the passenger coaches as coupled up in trains. A train consists of seven coaches, furnishing seating accommodation for 336 passengers, and, as events have

proved, standing space for a great many more. The weight of a train is about 100 tons empty, and 150 tons when loaded with the normal number of passengers. Figs. 36 and 37 are external and internal views of a typical carriage, the details of which are doubtless familiar to many of our readers. It is satisfactory to record the fact that all the coaches were constructed in this country, some by

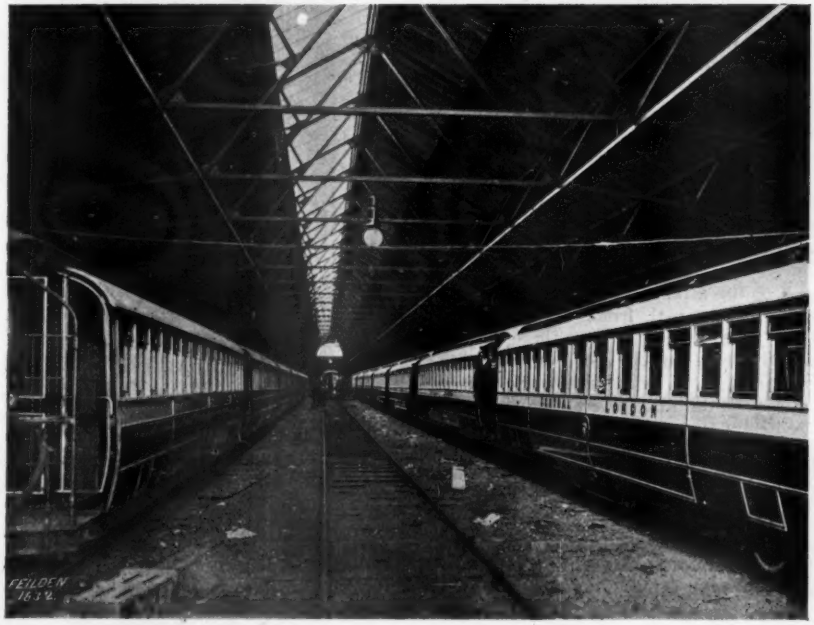


FIG. 35.—INTERIOR OF STABLING SHED.

the Brush Electrical Engineering Co., of Loughborough, and the remainder by the Ashbury Railway Carriage Co., Ltd., of Manchester.

All the electric locomotives were made in the United States, by the General Electric Co., of Schenectady, for the simple, familiar and highly unsatisfactory reason that British manufacturers could not guarantee delivery within the specified time owing to the unsettled state of the labour market. It is not at all clear why locomotives should have been adopted at all; their employment involves much useless dead weight for the purpose of obtaining the necessary grip on the metals, and consequently there is considerable waste of current. If the motors were directly attached to the carriages in accordance with the most recent practice the weight of the passengers would provide a much greater load per axle than is furnished by purely structural parts of the locomotive, and moreover, the axle load would necessarily be automatically adjusted to the required duty. Precedent may be partly responsible for the adoption of the system in question, but it is satisfactory to find that it has not been followed on the Metropolitan District Railway and elsewhere. Separate locomotives have been avoided on the Paris Metropolitan Railway,

and in the United States their use would not be seriously considered in the present day. In fact, it was remarked a few months ago by a well-known electrical engineer, that on the occasion of a visit to the Schenectady Works the mechanics then engaged in the construction of the locomotives for the Central London Railway, appeared to be surprised, not to say amused, at the idea of such machines being applied in this country. Apart from these considerations, it must be admitted that the locomotives themselves are of convenient design, each having a cabin with look-out windows, permitting a good view in either direction, and where all the apparatus, under the charge of the driver, is either in sight, or is readily accessible for control and adjustment. Fig. 38 shows the external appearance of a locomotive, and also a portion of the engine-shed, capable of holding 24 locomotives, and in which they were all erected after delivery in this country. A more exact idea of the arrangement and construction will be obtained from examination of Figs. 39 and 40. It may there be seen that the length of the locomotive over the buffers is 29 ft. 8 in., and over the body 26 ft. 7 in., the width overall 7 ft. 8 in., and the height above rail level, 9 ft. 4½ in.; the total weight is about 45 tons. The main girder frame is mounted on two 4-wheel bogie trucks (Fig. 43), the wheel centres of each truck being 5 ft. 8 in. apart, so that curves of small radius may easily be passed. Each of the four axles is furnished with a gearless motor of 117 h.p. Extending from end to end above the motors is a timber floor, over the centre of which is the driver's cab, containing the controller and other necessary appliances, whilst the space at each end is occupied by resistance coils, arranged on either side of a central passage way, and covered with a sloping roof of sheet-iron. The complete motor has an armature 1 ft. 10½ in. in diameter, and four field coils. It is enclosed in an iron case, provided with an access door (Fig. 41). By means of the series parallel controller, of which full details are given in Fig. 42, the speed of the locomotive may be regulated with due regard to economy. On starting, all four

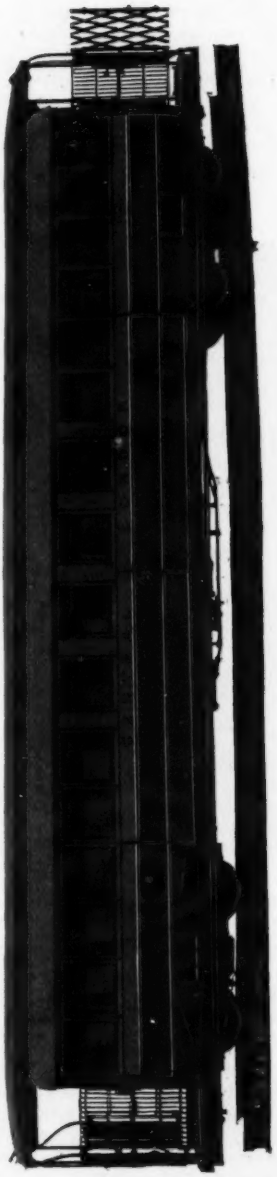


FIG. 36.—EXTERIOR OF PASSENGER COACH.

FIG. 37.—INTERIOR OF PASSENGER COACH.
(From a Photo furnished by the Brush Engineering Co., Ltd.)

motors are placed in parallel in pairs, and the two pairs in series, a resistance being then in series with each motor. One pair of motors is then progressively short-circuited, and all four are finally placed in parallel. The external working parts of the controller consist of a lever attached to the projecting vertical shaft and two reversing levers, placed on either side of the controller. The reversing and regulating levers are interlocked so that neither can be used unless the other is in a proper position. Upon the top of the controller is a ratchet dial serving the double purpose of indicating the position of the contact cylinder and of preventing it from being placed by the lever at an intermediate position between two working stops. There are in all sixteen stages in the regulation from zero to full speed. Current is collected from the third rail of the track by means of two cast-iron shoes, from which the current passes to the controller through an automatic circuit-breaker and switch, attached to the roof of the cab immediately above the controller; it then passes to the motors, and lastly to the metals through the wheels of the bogie trucks. Duplicate measuring instruments are placed in the cab, one set at each end, so that the driver may always have them in full view. A Westinghouse brake apparatus, of which the air-compressors are driven by a small motor, is included in the locomotive equipment; this motor is under automatic control, and maintains a constant pressure of 80 lbs. per square inch in the reservoirs, supplying air for the brakes and for sounding the engine whistles.

The third rail, through which current is conveyed to the locomotive, is of mild steel, and is of channel section, weighing 85 lbs. per yard. It is supported on stoneware insulators, as shown in Fig. 44, spaced 7 ft. 6 in. apart, and the joints are quadruply bonded with flexible crown bonds. The return current passes through the ordinary running rails (Fig. 45), which are also of steel, of bridge section, weighing 100 lbs. per yard, the joints being doubly bonded with crown bonds.

Turning now to the distribution of current, it may be said generally that the power transmission scheme involves the conveyance of high-tension current at 5,000 volts from Shepherd's Bush to three sub-stations constructed at the bottom of the lift shafts at Notting Hill Gate, Bond Street and Post Office passenger stations. At each sub-station the alternating current has to pass through step-down transformers, where it is reduced from 5,000 to 305 volts; and through rotary converters, from which it enters the sub-station bus-bars as direct current at 500 volts. From the bus-bars feeders are carried direct to third rail, and to the running rails. At an early stage of the undertaking a careful consideration of the relative merits of the three-phase and the three-wire systems was made by the British Thomson-Houston Company. It is unnecessary to enter upon a detailed discussion of these methods of distribution, as the general advantage of the three-phase system is sufficiently shown by Fig. 46. This diagram constitutes a summary of two series of curves prepared by the British Thomson-Houston Company, and which were based upon practical experience of both systems. Fig. 47, gives the output of each sub-station, with the losses and constants for a two-minute service, and shows that the average drop on the line is exceedingly small. Rheostatic losses are therefore minimised, and satisfactory lighting is ensured.

Four independent cables run from the generating station to Notting Hill Gate and Bond Street, and two of these are continued to the Post Office. Two cables are carried along each tunnel on brackets, as illustrated in Fig. 46, the supports being bolted to the flanges of the cast-iron tunnel lining, and the cables are protected by sheet-iron guards extending throughout the whole length of the tunnels.

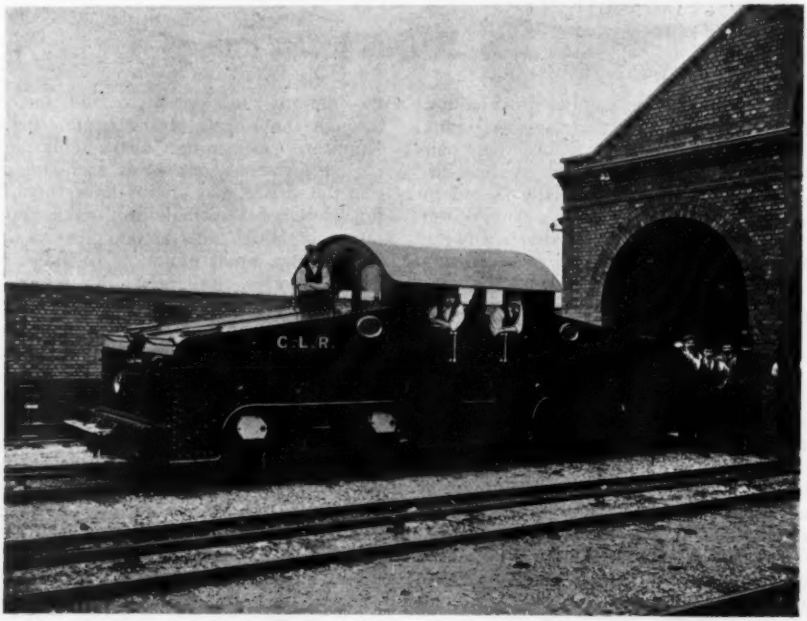


FIG. 38.—LOCOMOTIVE NO. 24, OUTSIDE ENGINE SHED.

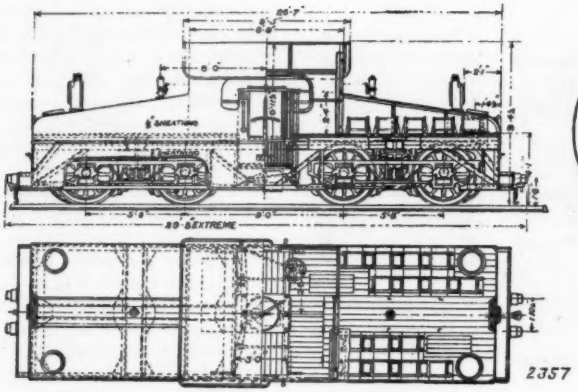


FIG. 39.—PLAN AND ELEVATION PARTLY IN SECTION OF ELECTRIC LOCOMOTIVE.

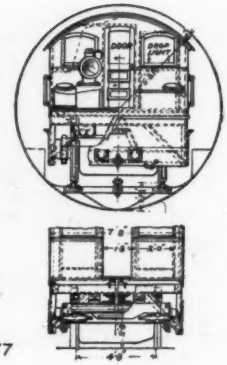


FIG. 40.—SECTIONS OF ELECTRIC LOCOMOTIVE.

At Notting Hill Gate the cables are taken into connection-boxes where any cable may be cut off from the system, or the sub-station may be isolated. A similar arrangement is adopted at Bond Street. The total length of high-tension cable is nearly 20 miles, and the weight is more than 78 tons. All the cables were tested in the first place with 15,000 volts, and with 10,000 volts for one hour after they had been fixed in position.

A typical sub-station is shown in Fig. 49, and it may not unreasonably be thought that the available space is undesirably small, considering the immense power capacity of the machinery. The plant includes seven transformers, two rotary converters, together with switchboards and other auxiliaries. The transformers are of the air-blast type, with two blowers made by the Buffalo Forge Co., driven by three-phase 6 h.p. induction motors. Hot air is drawn away from the transformers, and expelled through sheet-iron ducts carried up the centre of the passenger staircase, as shown in Fig. 49. Details of a transformer are given in Fig. 50, but it should be remarked that all the transformers are connected with the switchboard in such manner that any one or all of them can be used. The efficiency of the transformers is 95 per cent. at $\frac{1}{4}$ load, 97·17 per cent. at $\frac{1}{2}$ load, and 98 per cent. at full load. The secondary windings are carried down to bus-bars conveying current to the converter panels of the switchboard.

From these, the current passes to the rotary converters, the constructional features of which are sufficiently explained by Figs. 51 and 52. The bearings, magnet frame,

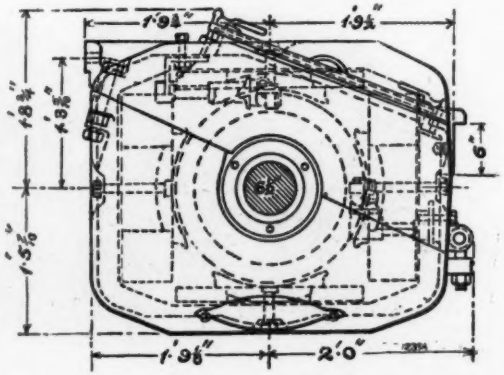


FIG. 41.—DRAWING SHOWING IRON CASING AND POSITION OF MOTOR ON LOCOMOTIVE AXLE.

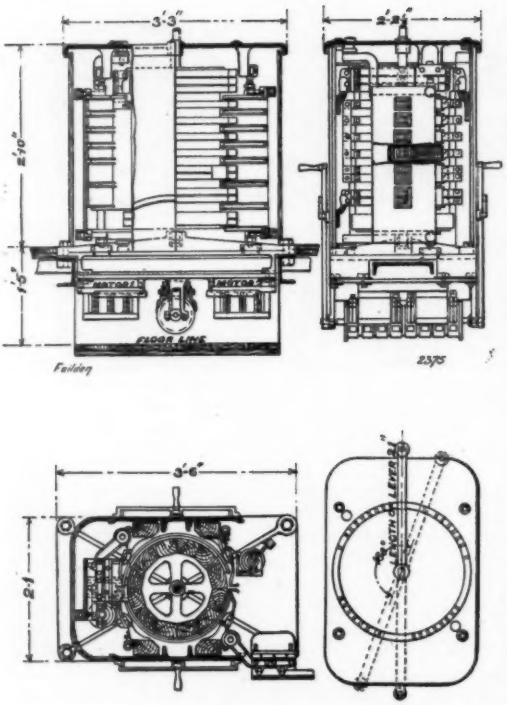


FIG. 42.—PARALLEL CONTROLLERS FOR ELECTRIC LOCOMOTIVES.

and collector gear are supported by a cast-iron base, the frame is of cast steel, and can be slid bodily along the bed-plate so as to expose the armature, which is built up of laminated steel plates, secured to a heavy cast-iron spider-wheel. The converters are twelve-pole, running at 250 revolutions, and are fed with three-phase currents at 25 periods per second, the potential difference between the collector rings being 330 volts. The efficiency of these machines at full load is 95 per cent., and at half load about 92½ per cent. The output is 1,800 amps. at 500 volts, which equals 900 kilo-watts.

Returning to the switch-board, of which a photograph is reproduced in Fig. 53, we find two converter panels and four feeder panels. Each of the latter is fitted with circuit-breakers, double throw quick-break switches, and a Weston ammeter. It should be noted that the feeder switches can be disposed so that the third rail is independent of any one sub-station, and can be fed by the others. In another position of the switches the positive bus-bar is coupled directly with the third rail.

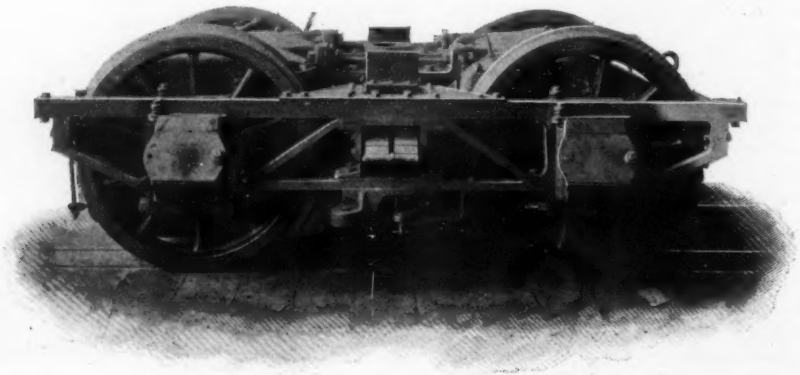


FIG. 43.—ELECTRIC LOCOMOTIVE BOGIE TRUCK.

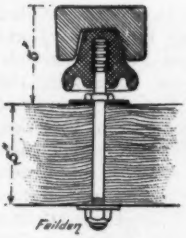


FIG. 44.—THIRD RAIL FOR CURRENT TRANSMISSION.

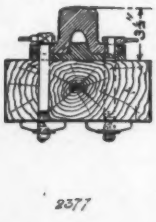


FIG. 45.—TRACK RAIL.

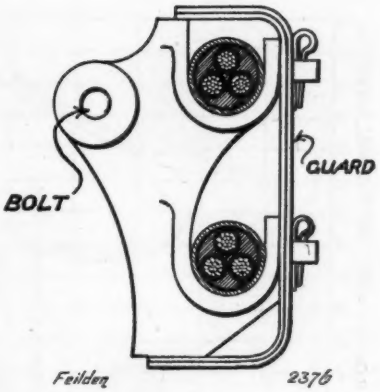


FIG. 46.—BRACKET SUPPORTING CABLES IN RUNNING TUNNELS.

Permanent connection is made between the negative bus-bar and the running rails, the energy supplied to each tunnel being registered by two Thomson watt-hour meters. Switches controlling the blower motors, and a ventilating fan motor, are mounted on the lower portion of the feeder panels. Adjoining the latter is a panel carrying the instruments controlling the lift cables, disposed one in each tunnel throughout the whole length of the line. An alternative feed for these is possible, as in the case of the third rail, and the current consumed is similarly recorded. For lighting purposes positive and negative feeders run the entire length

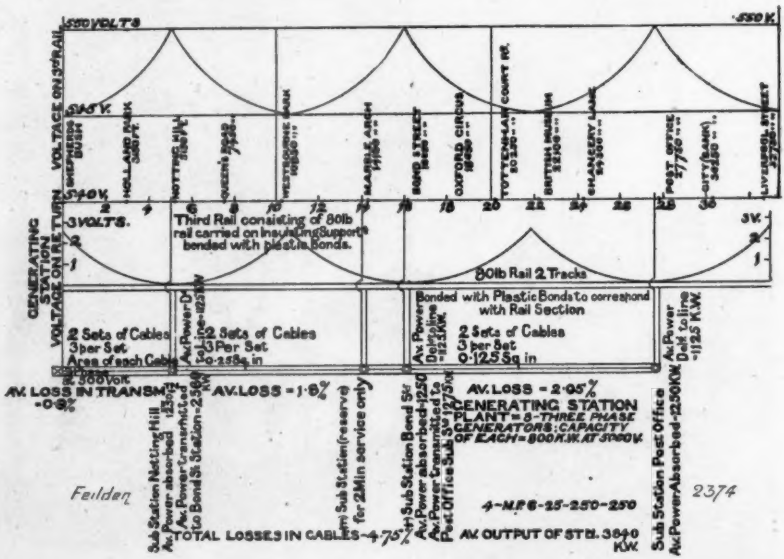


FIG. 47.—DIAGRAM SHOWING LOSSES AND CONSTANTS FOR A TWO-MINUTE SERVICE ON THE THREE-PHASE SYSTEM.

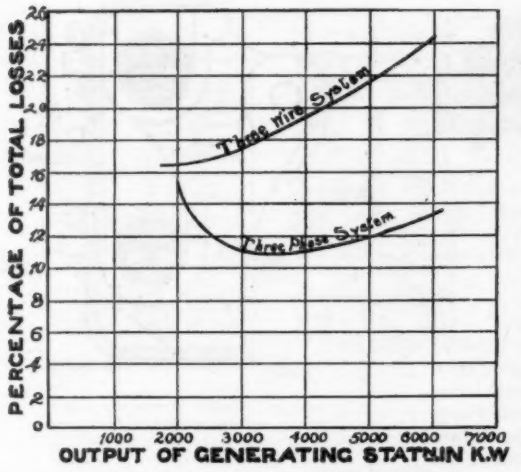

PERCENTAGE OF TOTAL LOSSES
Three Wire System
Three Phase System
1000 2000 3000 4000 5000 6000 7000
OUTPUT OF GENERATING STATION K.W

FIG. 48.—COMPARATIVE TOTAL EFFICIENCY OF THREE-PHASE AND THREE-WIRE SCHEMES.

of each tunnel, distributing-boards in the different stations being connected on the three-wire system. Three battery switchboards by Crompton & Co., Ltd., have been installed at Notting Hill Gate, Bond Street, and Post Office sub-stations, for controlling the charging and discharging of the 500-volt lighting batteries. Each board (Fig. 50) consists of three white marble panels mounted in an iron frame. On the left-hand side are four positive and negative feeder main switches and fuses, two integrating meters for registering the battery charge and discharge, a battery recording ammeter, and a main switch for the positive of the battery circuit. On the centre panel are a main switch for the negative of the battery circuit, a Crompton dead-beat central zero charge and discharge

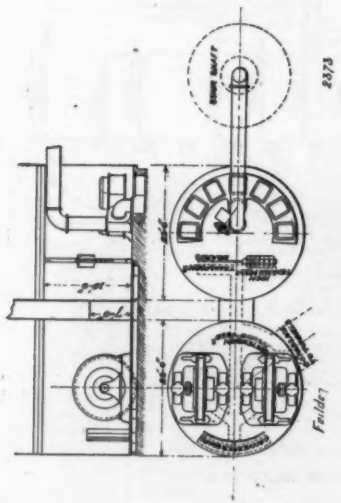


FIG. 49.—PLAN AND SECTION OF A SUB-STATION.

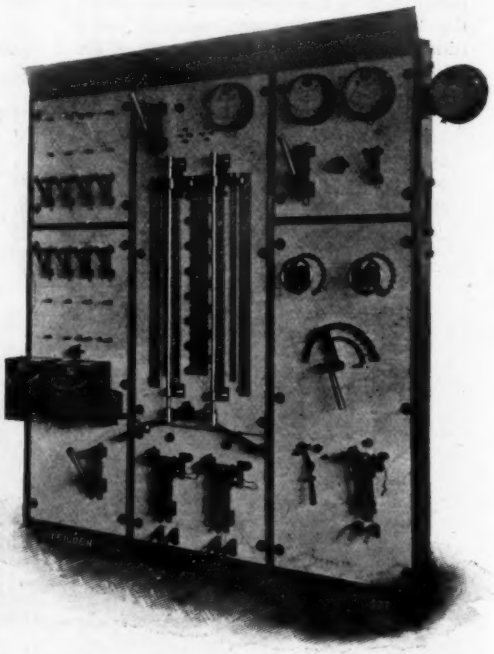


FIG. 50.—BATTERY SWITCHBOARD FOR LIGHTING. (CROMPTON AND CO., LTD., MAKERS, CHELMSFORD).

FIG. 51.—ROTARY CONVERTER IN SUB-STATION.

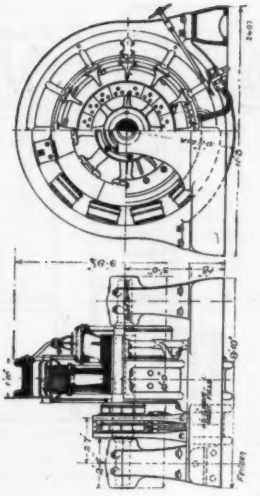


FIG. 52.—DETAILS OF ROTARY CONVERTER IN SUB-STATION.

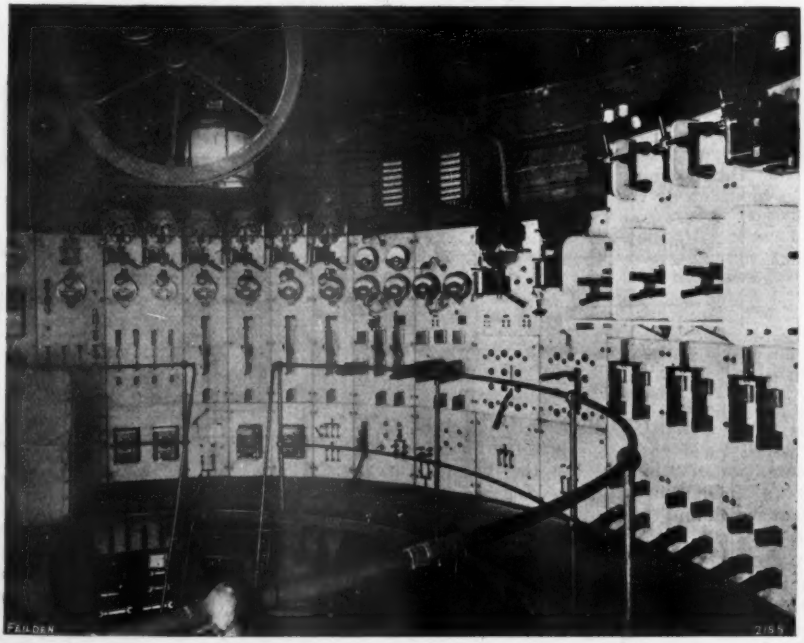


FIG. 53.—SWITCH-BOARD IN SUB-STATION.

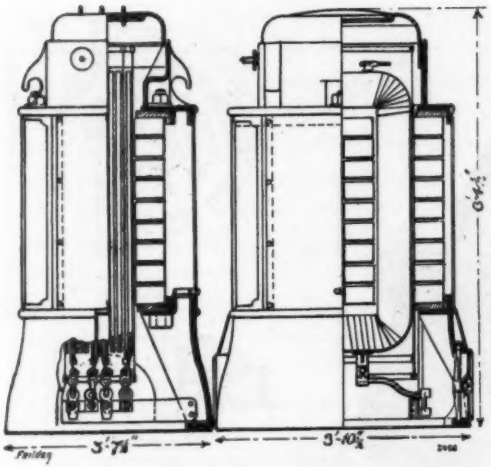


FIG. 54.—TRANSFORMER IN SUB-STATION.

is attached to a hinged bracket at one end of the switch-board frame. For charging the lighting batteries, three 25 kilo-watt "Booster" sets were furnished by Easton & Anderson, Ltd., of Erith. One of these sets is illustrated by drawings in Figs. 55 and 56. The charging current is 70 ampères, and the booster raises the voltage as required from 50 to 250 volts. The stations are lighted both by arc and incandescent lamps, and as a precaution against breakdown the arc lamps in one side of the station, and the incandescent lamps in the other are supplied by the main in the "up" tunnel, whilst the main in the "down" tunnel supplies the

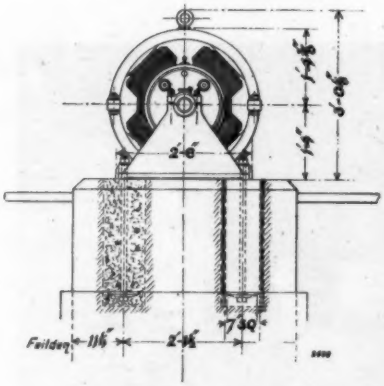


FIG. 55.—END ELEVATION OF "BOOSTER."

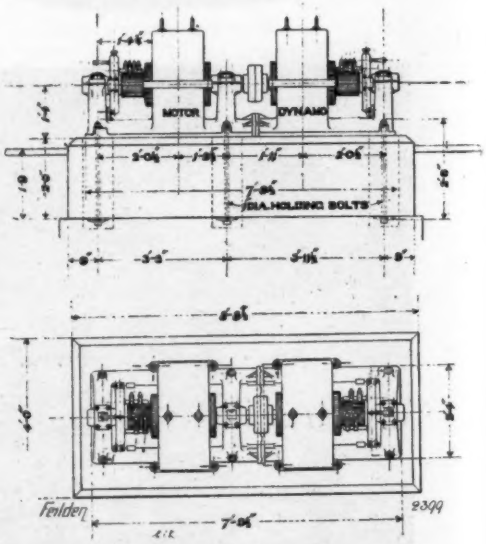


FIG. 56.—PLAN AND ELEVATION OF "BOOSTER."

battery ammeter, regulating switches and two circuit-breakers. The right-hand panel contains fittings for the booster circuits. On the secondary side are the main switch and the minimum automatic cut-out and a central zero current indicator. On the primary side a main switch, current indicator, 16-way starting switch and field breaking switch. Two shunt resistances and switches are also included. A dead-beat voltmeter

remainder of the lamps in both sides of the station. It is, therefore, impossible for the lighting to be interrupted unless both mains should break down simultaneously.

(To be concluaea).

W. H. Taylor

Machinery Appliances and Processes

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

1,000 K.W. FERRANTI ENGINE AND ALTERNATOR.

THE subject of the Supplement Plate this month is the 1,000 K.W. Ferranti Engine and Alternator, now running at 167 revolutions per minute at the South London Electric Supply Corporation's Works, Loughborough Junction, London.

The alternator is placed between the cylinders of the engine, the armature being built on a heavy fly-wheel, which is itself mounted directly on the crank-shaft. The fly-wheel comprises two cast-iron halves, each casting consisting of a rim of heavy section joined to a segmental hub by three arms. The two halves are joined together, and at the same time the wheel is caused to grip the shaft by shrinking steel rings of massive section over prepared bosses on the hub and rim. In addition to the six above-mentioned cast-iron arms, between each there is inserted a stout steel tie-bolt, the head of which fits into a machined recess in the rim, and the end screws into a steel hoop shrunk on to the shaft and lying inside a cored recess in the cast hub. These bolts are heated prior to being screwed home, and on cooling put a compressional stress in the rim; thus the wheel is well stiffened to bear the stresses due to its high surface speed.

The armature, which is of the well-known "Ferranti" disc type, and consists of 36 coils, is erected on the rim of the fly-wheel. Each coil or bobbin is built up of a number of turns of copper ribbon wound round a brass laminated core, each turn being insulated from its neighbour. The coils are rigidly mounted in pairs between two brass brackets or carriers, and these are firmly bolted to bolts projecting from cavities in the wheel rim, but thoroughly insulated from the rim. The bobbins are connected together by specially designed connections, the high-tension terminal of the machine being joined up to a brass ring of small diameter, and therefore small surface-speed, which is mounted on insulated studs let in holes in the wheel-boss.

The frames which carry the field-magnets consist of two cast-iron rings, each of which is built up of four quadrants firmly bolted together, two of these four being cast with feet which, resting on the substantial girder bed-plates, support their own weight, together with that of the mounted field-magnets, windings, etc.

The magnets and magnet-faces are made from high permeability iron, and are carefully machined, fitting accurately into equally pitched holes in the magnet-frames, the faces being adjusted into one plane at right-angles to the shaft. The field-winding is copper-strip wound to shape on mandrils and then slipped on to the magnet. The coil is efficiently insulated from the frame-casting, and also from the magnet, and each turn of the coil is well insulated from the adjacent ones.

The field-coils are excited by the current from a small generator driven from a rope-pulley on the crank-shaft. The magnet-frames open transversely to facilitate cleaning operations, the gear provided for so opening them consisting of screw-shafts with right and left-handed sections, which work in nuts in the frames, and are driven by chain-gear from a controlling hand-wheel, rollers under the frame-feet rendering the power required a minimum. By means of this opening-gear the air-gap of the machine may be varied at will, the desired position being maintained by distance-bolts pitched at frequent intervals round the outside lip of the frame.

STEAM TURBINES FOR ELECTRIC LIGHTING.

THE Borough of Cambridge was one of the early provincial towns to be supplied with electricity for lighting and other purposes. The Corporation obtained a Provisional Order in 1890, but, being unwilling to embark the ratepayers' money on what was then a somewhat uncertain venture, they sold (after nearly two years) their order to the Cambridge Electric Supply Co., Ltd., for £1,000. Although the company was only registered in May, 1892, on November 19 of the same year—six months after—a station had been built, mains laid, and three Parsons' steam turbines and alternators of a total capacity of 360 kilo-watts were supplying the University and town with electricity.

The history of this station is a record of the efficiency of the steam turbine and of the advantages of this machine. That a complete installation of this size could be finished in so short a time was largely due to the requirements of a small site and the absence of massive foundations. The engine-room is 35 ft. by 49 ft., with a total floor space of 1,715 square ft.; in this space there will shortly be installed seven engines and alternators, each complete with its own condenser, pumps and exciter. Three sets of 120 kilo-watts each were erected, as mentioned above, in 1892, a 75 kilo-watt set in 1896, a 35 kilo-watt set in 1898, and a 500 kilo-watt set in January of this year, to be followed by a second of the same size during the present summer. The directors obtained tenders for the plant of the size last-named from all the leading engine and dynamo makers in the country, but the available space in the engine-room would not accommodate one set of plant (without condenser and pumps) offered by the makers other than Parsons & Co., either in floor space or headway, but in this same space two complete 500 kilo-watt turbine sets, condensers and pumps, will shortly be fixed and leave ample room all round.

When these extensions are carried out the capacity of the station will be 1,470 kilo-watts, but, by removing the first five turbines installed and substituting three 500 kilo-watt sets, the capacity could be raised to 2,500 kilo-watts, equal to that of St. Pancras, Birmingham, Leeds, or Kensington, according to their last return. A station the writer has in mind, equipped with some of the most recent engines of another type, has a floor space of 160 ft. by 45 ft., equal to 7,200 sq. ft., and contains 2,800 kilo-watts; the ratio of this, compared to Cambridge, is as 4 to 1. In a large town the value of such land and the possibility of obtaining a convenient site of this area is a serious consideration, to say nothing of the cost of larger buildings and heavy foundations.

The weight of the early engines and alternators was extremely small: each of the first 120 kilo-watt sets only scaled 5 tons, at the rate of 24 kilo-watts per ton; more recent ones are somewhat heavier, as they are erected on a continuous bed-plate, the 500 plant weighed 20 tons 5 cwt., or 25 kilo-watts per ton, against 37½ tons, or 13⅓ kilo-watts per ton for one of the sets offered by another maker. The weight of machinery is the first consideration in the construction of foundations, and equally important in this respect are vibration, need of holding down, and capability of the engines running out of level. These items were of great moment at Cambridge; the engine-room is situated by the Cam on a mud bank, and it was not considered necessary to pile or adopt any precautions beyond those needed to secure the walls of the buildings themselves. One end of the engine-bed had subsided to the extent of 3 ins., and this was not discovered until new fireproof floors were being put in; the machinery worked equally well on the incline. No holding-down bolts are used and the bed-plate is laid on teak blocks 2 ins. thick with a strip of lead ⅛ in. thick nailed to the upper surface, the only rigid connections needed being the steam and exhaust pipes. In a large London station an injunction was obtained by the residents in the neighbourhood to compel the company to stop running the engines on account of the vibration caused by the reciprocating parts; this practically meant closing the place until turbines were tried, and then the complainants expressed themselves satisfied that the nuisance had been abated.

With light engines and this freedom from vibration, it is possible to place turbine sets on a floor supported on beams or pillars and utilise the space below. In the 500 kilo-watt set the space below is open, and the surface condenser and pumps are directly under the main engine, not only economising space, but allowing of very short and direct exhaust pipes, and the maintenance of a high vacuum at the engine itself. Accessibility to the interior and to the bearings is an easy matter, and repairs can be executed by few men using appliances of a simple nature; in the same way erection is facilitated by the portability of the parts, and was well illustrated at these works during the winter of 1899. Through the general pressure of work

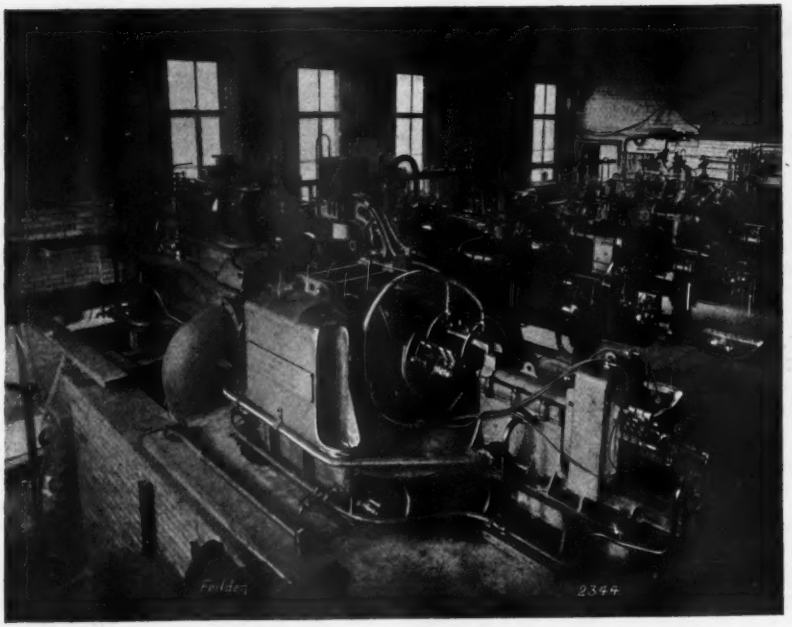


FIG. 1.—CAMBRIDGE ELECTRIC SUPPLY CO., LTD. : VIEW OF ENGINE-ROOM WHEN FIRST COMPLETED.

the contractors could not deliver the last engine in time to meet the heavy load, and they therefore agreed to lend a plant for three months, of 120 kilo-watt capacity ; all the space in the engine room was in the builders' hands preparing for the permanent plant, the only spot that could be used was a corner of the pump room, 9 ft. below the engine-room level, with the bare earth for foundation. The soil was levelled and four pieces of timber 12 in. by 12 in., 3 ft. long, were laid at intervals at right angles to the length of the engine and alternator, which was erected on the top of the timber without holding-down bolts of any sort, a 3-in. steam-pipe was connected to the stop-valve, a 10-in. exhaust pipe carried through the wall, and a pair of cables carried to the switch-board, when, for less than £5, the plant was complete and ready for work. It ran until the delivery of the 500 kilo-watt set and worked as well as any of the permanent engines. A photograph taken from the engine-room floor shows this plant in its extemporised house.

The wearing parts of turbines are few :—Omitting the electrical governor and oil-pump, a direct-current engine and dynamo have but four, and an engine and alternator with its own exciter six—namely, the bearings of the motor and armature shafts. The weights of the moving parts are small, and the journals for a 120 kilo-watt plant are $1\frac{1}{2}$ in. in diameter, whilst the 500 kilo-watt is 3 ins. The bearing itself is a phosphor-bronze tube, and round this are fitted three steel tubes, each nearly the full length of the bearing, and concentrically over each other, with a small amount of play between each. The whole is immersed in a bath of oil, circulated by a pump. The lateral freedom enables the shaft to take up a perfect alignment, and the viscosity of the oil between the tubes themselves and the bearing absorbs any vibration that may be set up. The life of these bearings is remarkable ; to use a term borrowed from makers of reciprocating engines, they are always in thrust, and more than that, the thrust is merely the weight of the rotating parts, and is not dependent on turning effort or affected thereby. A plant at Cambridge was overhauled a short time ago after running for a year and ten months ; the running

hours equalled 340 days of 24 hours each; the revolutions in this time had been 2,937,000,000 (two thousand nine hundred and thirty-seven millions); to give some idea of what this means, if the armature had been supported by its journals resting on two rails 3 ft. apart, and the rails extended round the equator, it would have travelled $8\frac{1}{2}$ times round the world at the rate of 738 miles a day on wheels only $1\frac{1}{2}$ in. in diameter. The wear on these armature bearings was, when measured against a new duplicate bearing, about ·015 in. The bearings cannot be said to run cold, for the proximity of the bearing at the high pressure end to the steam cylinder maintains the oil at a temperature of about 80 degs. Cent.; in spite of this, hot bearings are of rare occurrence, engines have been run for three weeks without stopping or withdrawal from the supply mains, and three monthly runs with the same oil used over and over again are the usual lengths of time without filtration, a pint or so a day being added to make up for waste.

It is often urged that steam passing over brass blades at so high a velocity as is maintained in the interior of turbines must seriously cut away their sharp edges and impair the efficiency of the machine; the writer has made many observations to confirm or disprove this. One of the first engines was a week or two ago opened, and the most careful examination could not reveal the slightest deterioration or wear from this cause; the file marks are distinctly visible on each blade, and the edges as clean and sharp as when they began work seven years ago.

The control of the turbines is very simple, and at Cambridge they are entirely self-governed by an electrical control referred to below. The whole engine-room staff is eight —two engineers, three firemen, and three cleaners; at top load there are four on duty for two hours, and then three. On Sundays and during the summer, from two a.m. to six a.m., a single fireman takes entire charge without difficulty. It must also be said that this staff of eight undertakes the whole of the repairs and upkeep, and does all the erecting of new plant or extensions of any sort (with the exception of boilers).

The internal arrangement of these steam turbines is akin to the water turbine, except that it is a series of many turbines attached to the same shaft through which the steam passes successively and expansively, each succeeding turbine being designed for a larger volume of steam than its predecessor. The steam is admitted in gusts at full boiler pressure at the rate of about 150 gusts per minute. The duration of each gust is regulated, according to the work required, by means of a relay which, in turn, is adjusted by the electrical or centrifugal governor, according as the requirements are, constant speed or constant volts. The simplicity and

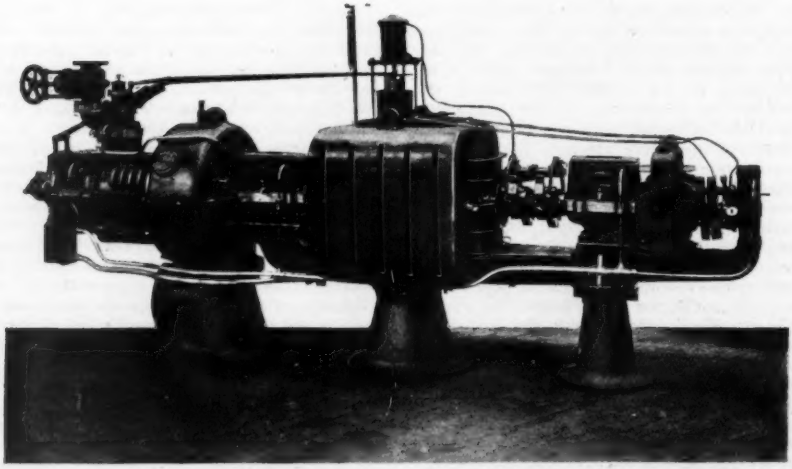


FIG. 9.—CAMBRIDGE ELECTRIC SUPPLY CO., LTD.: 120 RADIAL-FLOW TURBINE SET.

FIG. 3.—CAMBRIDGE ELECTRIC SUPPLY CO., LTD.: VIEW OF ENGINE-ROOM WITH 500-K.W. PLANT.

ingenuity of the admission and governing gear are very remarkable, and the performances are excellent. The turbines owe their efficiency largely to the very small internal friction; the amount of this is that due to the revolution of a perfectly balanced fly-wheel in two small bearings, and, to a smaller degree, the friction of the blades against the passing steam, with this advantage—that the last degree of expansion can be utilised. Precautions are taken when working condensing to obtain as high a vacuum as possible. With jet condensers and compound air pumps (built by Parsons & Co.), the gauge can be maintained at a reading only ½ in. below the barometer. To obtain any work from the last four or five inches of vacuum in a reciprocating engine, the size of the cylinder must be made out of all proportion to the result obtained, and this, instead of giving out power to do useful work, may absorb energy from the remaining parts of the engine to overcome its internal friction and inertia. The rotating weight of the moving part of a turbine of 700 b.h.p. which transmits the energy contained in steam at atmospheric pressure expanding down to vacuum is some 600 lbs., and the friction that of a fly-wheel of equal weight in its two bearings.

The efficiency is further increased by the absence of interchange of heat between the steam and various parts of the engine; every part of the turbine is maintained at a constant temperature, that of steam at a pressure corresponding to the period of expansion in each successive turbine.

Priming boilers have no terrors for the users of turbines—water passes through without damage to the engine at all. A driver of high-speed reciprocating engines was asked: "What do you do when your boiler 'primes?'" His reply was, "Wheel the pieces away in a barrow." The turbine driver, if he does heed priming, holds the governor valve full open to pass all the water possible at once.

As no internal lubricant is needed for turbines, the condenser gives absolutely pure water and causes no injury to boiler plates or tubes, as does the water from all other engines with some fatty acids, however good a filter may be used.

To all these advantages the turbine adds that of the highest commercial efficiency. In 1892 one of the first Cambridge engines was tested by Professor Ewing at the maker's works, who thus speaks of its performances: "When the output was at a rate approaching 150 effective h.p., the steam was expanded from an absolute pressure of 115 lbs. per square inch to 1 lb. per square inch, and the amount of steam which was used per h.p. hour was not more than it would have been in a first-class compound engine." And again, "The Willans line for the steam turbine is very nearly straight, and the rate of output may be reduced to one-half

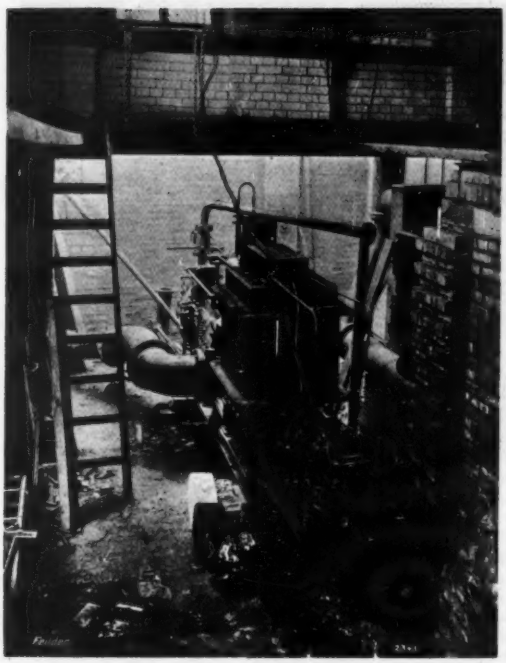


FIG. 4.—CAMBRIDGE ELECTRIC SUPPLY CO., LTD.: TEMPORARY 120-K.W. PLANT.

the full load or less, with no more than a small increase in the consumption of steam." The year 1892 was in the comparatively early days of steam turbines, and since that date great advances have been made in their performances. As previously referred to in this article, the directors of the Cambridge Company invited tenders from five leading engine and dynamo builders before ordering the sixth engine and alternator. The prices given are shown below.

It practically amounted to this: that from Parsons & Co. an engine and alternator with a surface condenser and pumps were obtained for the same money as for engine and alternator in three other cases. The cost of such a condenser and pumps was about £1,000. The guaranteed performances promised by Messrs. Parsons & Co. were higher; all the other makers claimed an allowance of five per cent., increasing their figures by 1¼ lbs. of steam per kilo-watt hour, and, further, the Parsons figures were to include the power absorbed by the air and circulating pumps.

In October, 1899, the writer made tests of this engine at Newcastle. The condenser and pumps could not be attached as they were already built into position at Cambridge; the consumptions are therefore comparable with the rival makers' guarantees, but it is probable that slightly better figures could have been reached with the increased vacuum gained from a condenser close to and without the long test-house exhaust main.

The results of these tests are tabulated on page 369.

These figures were obtained without superheating. With a pressure of only 127 lbs. of steam per square inch 22·4 lbs. of steam per kilo-watt hour is a remarkably good result, and the half-load performance of 27·5 lbs. of steam per kilo-watt hour, equal to the full load guarantee of any other maker is even more creditable.

The exciting current at 600 kilo-watts was only ·58 per cent.

Table showing tenders for engine and alternator for the Cambridge Electric Supply Co., Ltd.

Firm.	Price.	Guaranteed performance in lbs. of steam per kilo-watt at 140 lbs. condensing.		
		Overload, 625 kilo-watt.	Full Load, 500 kilo-watt.	Half-load, 250 kilo-watt.
	£			
A	4,100	—	28	34
B	5,456	25·5	27	32
C	4,880	—	28	34
D	5,010	—	26·7	32·2
Parsons & Co.'s includes condenser and pumps... ...	4,824	—	27	30

Table showing results of tests of Steam Turbine set for the Cambridge Electric Supply Co., Ltd.
(See previous page.)

Boiler pressure... ...	lbs.	127	139	145	140
Vacuum	...	24·75	24·5	26·5	27·5
Barometer	...	29·6	29·6	29·6	29·6
Water per hour ...	lbs.	13,400	12,675	7,029	4,180
Output in kilo-watts ...	...	598	526·4	256·1	124
Water per kilo-watt ...	hour	22·4	24·1	27·5	33·7
Exciting current...	kilo-watt	3·5	3·3	3·1	3·0

HOWDEN'S OIL BURNER.

THAT voyages may be completed with perfect safety with liquid fuel instead of coal as steam raiser, has now been fully demonstrated by the voyage of the *Comrie*. This vessel is one of the Shell Transport Company's steamers, of 4,893 tons gross, and built by Mitchell, Armstrong & Co., for the oil trade from the Transport Company's fields of Borneo. She sailed from London burning coal in her furnaces until she reached Bombay. At Bombay, crude oil was taken in from the company's stores, and this oil was fed to her furnaces until she reached Balak Pappan, on the east coast of Borneo. Here she took in a cargo of oil and returned to London, burning crude oil all the way. At London she took in gas-house refuse, and a mixture of this and oil was burned in a voyage to New York. On the voyage from Bombay to Balak Pappan and back to London, the engineers, after careful trial, observation, and determination of the necessary conditions, arranged the burners to work so that no deposit of oil or refuse was left in the tubes. On the voyage from London to New York there was not quite the same marked success; for, while gas refuse was used, frequent sweeping of the tubes was necessary. The thick refuse sometimes caused the oil feed-pipes to become stopped, but after steam connections were fitted to them, so that they could be blown through, this trouble was got over.

Altogether there was a great saving of labour. A complement of ninteen firemen and trimmers was required for the stokehold while coal was burned in the nine furnaces of the three boilers on the voyage. But the numbers were reduced to nine Chinamen when the oil burners were in use. Some trouble has sometimes been found with different burners. The noise when steam is used to pulverise the oil is an annoyance and a great waste. Mr. Howden intends to get over these difficulties by using air to pulverise the oil instead of steam.

Howden's system of forced draught is so well known that it will be superfluous to describe it in conjunction with this new oil-burning furnace of his. Suffice it to say, that his system of heating the air to be used to pulverise the oil, as well as for the draught, will be done by his well-known arrangement of tubes. This arrangement of heating tubes is shown in the up-take, Fig 1. It will also be seen that there is a pump at the left side of the drawing. The purpose of this pump is to supply the oil to the furnace through the oil nozzle at a considerable pressure. The nozzle is shown in Fig. 3, and it will be seen that the nozzle as fitted in (*a*) Fig. 2, is encircled with an annular space, through which the air for combustion flows into the furnace in such a manner that it mixes with the oil jets as they enter the furnace.

The force pump draws the oil from a tank through the suction pipe at the bottom of the pump, and discharges it through the pipe leading from the left downward horizontally, and then up to the nozzle at the furnace door shown in Fig. 1. There is an air receiver fitted on the left of the pump to this discharge pipe, so as to equalise the pressure and neutralise the pump pulsa-

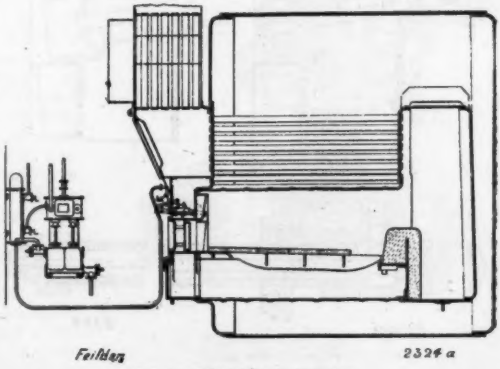


FIG. 1.—HOWDEN'S OIL BURNERS.

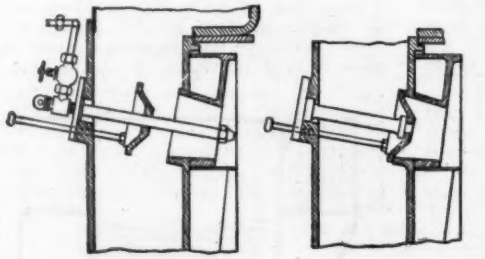
tions. Should the oil used be too thick to flow into the furnace in a fine spray, it is first heated. For this purpose a steam coil is fitted in the air receiver. There is also a filter within the air receiver, to drain the oil of solid particles and prevent the nozzle from becoming choked.

It will be observed that in Fig. 3 the nozzle is screwed into the inner end of the nozzle pipe, and that the quantity of oil flowing through the nozzle can be regulated by screwing in or out the inner end of the nozzle. There is also a screw arrangement at the back of the regulating cone, to give the oil a rotational movement, which assists in splitting it up into a fine spray. The oil enters the nozzle by the passage at the top, and flows, under the pressure given it in the receiver, along inside the nozzle and outside the regulator, till it reaches the screw behind the cone.

There is, as is usual with Howden's draught, a furnace with a hollow front, through which the heated air flows to mix with the oil. It will be noticed that there is a door in (*a*) Fig. 2, which can be pushed inwards by a rod attached to it until it closes the annular opening and prevents any further air entering the furnace. The door is shown closed in (*b*) Fig. 2, where air is completely shut off and combustion stopped. Between being fully open and being shut the door can be placed anywhere, and so the admission of air can be regulated in quantity as it flows into the furnace. In this arrangement there are two nozzles to each furnace, and each is supplied with a stop valve just above the place where it enters the furnace for regulating the supply of oil.

The air may be also admitted through ports above the crown of the door of the furnace, which ports are regulated by a valve and handle. The air from these ports passes into the furnace through perforations in the crown plate. The furnace is provided with an ordinary grate for burning coal in the usual way, but when oil is used, this grate is covered with brick slabs as shown in Fig. 1. Some of the slabs are omitted at the back of the grate, so that heated air may enter the furnace through the grate from the ashpit, and so improve the process of combustion. The admission of air to the ashpit is regulated by valves.

The apparatus is applicable to water-tube boilers as well as those of the cylindrical type, with which very good results have been obtained.



(*a*) FIG. 2. (*b*)

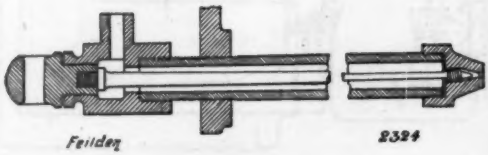


FIG. 3.
HOWDEN'S OIL BURNER.

AN IMPROVED FORM OF TRANSIT THEODOLITE.

An instrument that is now being constructed by the optical and mathematical instrument makers, Messrs. John Davis & Son (Derby), Ltd., forms the subject of this notice, and has peculiar advantages in that it can be not only employed for connecting underground tunnels to the surface, but, is also admirably adapted for every other class of surveying, unless indeed the underground main roads are too small to admit the use of a very low-formed tripod stand. The instrument is denominated "Hoskold's Civil and Mining Engineers' Transit Theodolite" (Patent), and has the general appearance of an ordinary instrument, but with the difference that it possesses various important improvements, and advantages in use, not found in other types of instruments.

For example, the internal vertical axis which is screwed to the horizontal vernier circle, is made a great deal larger than usual, and instead of being solid, it is perforated for its entire length, and has a cylindrical form; the hole through it being about 1 in. in diameter. This axis works in another or exterior vertical axis which is screwed to the underside of the horizontal divided circle, and this axis revolves in a socket which forms the central part of the levelling apparatus. In order to avoid too

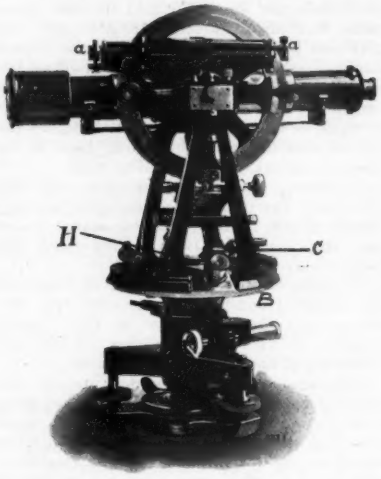


FIG. 1.—ORDINARY TRANSIT.

a—a. Trough compass fixed above telescope. May also be fixed at *B* under horizontal plate.
C. Prism reflector to light vernier.
H. Hollow centre for sighting down a pit shaft.

much friction, the exterior parts of the two axes, are, in two or three places, turned down below the general level. A corresponding hole to that in the central axis, is made in the centre of the horizontal vernier circle, so that a direct sight may be obtained through the telescope and centre of the instrument down a shaft, and in this way any underground tunnel may be connected to the surface in the same manner as by the use of the astronomical transit instrument.

The *modus operandi* is this: The Surveyor selects a point along the heading or tunnel leading from the shaft into the mine, as far from the shaft as may be necessary, or to the first bend in the road, and, having placed a permanent station there, attaches the end of a strong wire to it, and then stretches it along the level road towards and across the middle and near to the bottom of the shaft, and then the opposite end of the wire is made fast to the side of the shaft. Near to each side of the shaft the wire is strongly illuminated by electric lamps placed at a convenient distance below the wire; or some other contrivance may be adopted. For example, a certain class of metal may be used for the wire, and, after forming a circuit, it may be illuminated by an electric current. The size of the wire necessary to be employed, and which may be distinctly seen at different depths, may be determined at surface during the night time. The surveyor then fixes the transit theodolite upon a rigid platform over the centre of the shaft, and having brought the vertical spider's-line in the focus of the telescope to bisect the illuminated parts of the wire at the bottom of the pit, it is then raised to the horizontal, and the same base line marked upon the surface, to which all surveys should be referred. Naturally, some little time will be required to complete these operations accurately; but with ordinary care an underground line may be thus produced at surface, or *vice versâ*, within a very few seconds of the truth. The great importance of this process is, that as the same line forms the base of the underground and surface survey, all surface objects and distant boundary lines, dividing one mine from another, will have their relative correct position, and a point may be selected at surface from which a shaft may be sunk with a certainty that it will strike a given

FIG. 2.

D—D. Sights above telescope.
C—C. Prism reflectors to light verniers.
A. Trough compass fixed under horizontal plate.

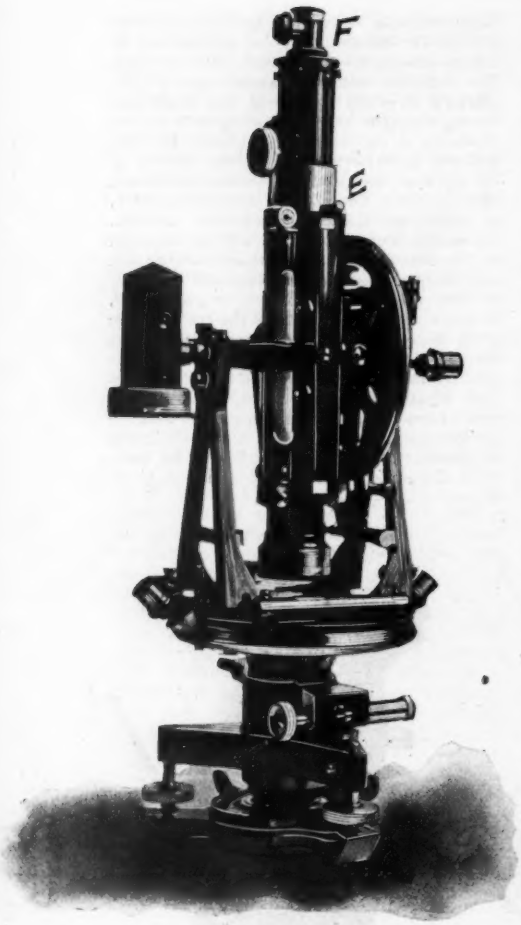


FIG. 3.—TELESCOPE FIXED VERTICALLY TO SIGHT THROUGH PATENT HOLLOW CENTRE DOWN PIT SHAFT.

E. Telescope raised through sleeve or axis collar to clear horizontal base enabling standards to be constructed shorter.

F. Diagonal eye-piece.

point below ground. In the case where such surveys have been carried out with rigid correctness, workings may be commenced below, and so drive the lower portion of the pit upwards to meet that portion sunk from the surface, and so lessen the time necessary to execute the work. This plan has frequently been carried out in the United States with excellent results. It should be observed that when the theodolite and its base apparatus has been moved laterally upon the platform previously noted, until the illuminated marks below ground appear in the field of the telescope, the nice bisection of the spider's-line with the illuminated marks is made by turning a screw, which causes the transit theodolite to slide with part of the base apparatus in a lateral direction.

Formerly, such a connection as that described was made by a magnetic bearing, which is the reason why so many errors have resulted, and it is to be regretted that even to-day it is still practised.

No plan for the transference of a surface line below ground can supersede that employed by Mr. Richards at the Severn tunnel; the reverse operation, of no less importance, has been fully indicated.

The new instrument under notice also possesses another very important improvement, *i.e.*, it is provided with a more powerful and longer telescope than can be obtained in instruments of the ordinary type, and of the same size and height of **Ys.** This has been attained by making the horizontal, axis socket, into which the telescope is ordinarily fixed, much longer than usual and the telescope is made to slide in this socket, so that when a perpendicular sight is required, the telescope is slid in the socket until its objective end will pass the vernier circle; and consequently, the nadir observation is taken. On the contrary, when a very high angle is required, or a sight to be taken to the zenith, the telescope is slid in the opposite direction, or until the eye end and a long diagonal eye-piece will pass the vernier circle. Thus, this special contrivance presents great advantages to an observer.

For ordinary land surveying, railway work or tunnelling purposes, the telescope is slid to its normal position, or half way in the axis socket and kept firm in that position by a clamp screw.

In the wide part of the thin metal arm carrying the microscopes for the horizontal verniers, a glass prism is fixed in a slight frame, having a horizontal revolution, so that when it is turned in the proper direction or angle, rays of light are collected and reflected to the vernier and that part of the divided circle under inspection. This little apparatus is exceedingly valuable underground as also upon the surface in dull days or night.

Besides these improvements, the instrument is divided upon platinum to read to 15 seconds, and it has a micrometrical eyepiece attached reading to one second of arc.

This arrangement is exceedingly useful for determining distances by Col. Tanner's sub-tense process, which consists in setting up a rod 20 ft. in length or other convenient length, in a horizontal position and at any distance, then measuring the angle between two metal discs, one of which is placed at each end of the rod. Then the distance may be found by the following simple rule :—

Say, Measured angle = 3° 10′ 31·4″; and sub-tense base = 30 metres.
Then Log. of base, 30 metres = 1·4771213
And Log. Co. secant of 3° 10′ 31·4″ = 11·2565632

2·7336845

And distance ... ... = 541·60725

Col. Tanner practised this system a good deal in India, and he states that it is superior in point of accuracy to any other plan short of a trigonometrical survey.

The micrometrical eye-piece attached to the new instrument, will also prove useful for a variety of purposes, including an auxiliary for measuring fine angles in connection with those obtained from the limb of the instrument.

All the parts of the instrument, excepting the bearings, bushings, and screws have been made of composite aluminium metal ; consequently it is much lighter than instruments of the old type, and of the same size, made in the usual metal.

A NEW LIFT AUTOMATIC BRAKE.

WE are still a very long way from being in possession of a perfect lift. It was only the other day that Sir F. Bramwell drew attention to the inefficiency of lift doors, and suggested one which would remove the danger to those not wholly conversant with them.

A dangerous condition of things is brought about when the shaft or supporting band breaks and the stopping of the lift from crashing down to the bottom is brought about by means of a brake. It is clear that the safety of anyone who happens to be in the lift when this takes place depends entirely on the efficiency of the brake. That brakes are not all efficient is proved by the numerous accidents which are recorded in the daily press from time to time.

It was while engaged on the repair of a lift that Messrs. Halket and Kennedy were struck with the necessity of an improved brake, and no sooner had they entertained the idea than they set about making experiments with a view to ultimately obtaining an

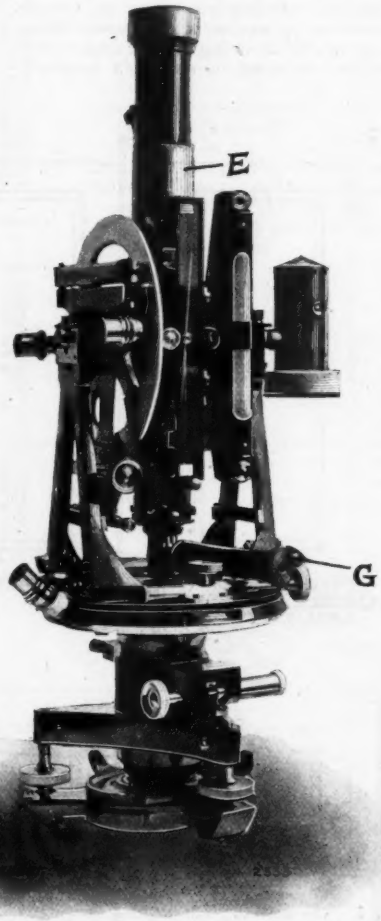


FIG. 4.—TELESCOPE FIXED VERTICALLY TO SIGHT UP A PIT SHAFT, ETC.
E. Same as *E* in Fig. 3.
G Long and diagonal eye-piece.

improved brake which could be entirely depended on to act under all conditions and to stop the lift under all circumstances.

The problem which they set themselves to solve was this. Supposing the raising attachment to break or give way either on the up-going movement of the lift or the down-coming motion, it was required to invent an apparatus which would be sensitive to the increased acceleration when the cage began to fall, and being sensitive to the increased downward acceleration to set a certain mechanism in motion which would bring into gear a brake strong enough under every condition to bring the cage to a standstill. The problem is not a simple one, for first of all a mechanism requires to be designed to be sensitive to an increase of downward acceleration and yet be insensitive to the accelerations and movements in connection with the ordinary working of the lift. Secondly, the mechanism which is sensitive to the increased downward acceleration when the raising or supporting force has become withdrawn must set in motion the real brake. Thirdly, the brake must not bring the cage to a standstill all at once, but gradually, for the strains to which the mechanism which brings a heavily moving body to rest all at once are so enormous that it is almost certain something will get broken and the cage be rendered as helpless as it would be without a brake. The brake then must be so constructed that when set in action it does gradually and by an increasing force bring the cage to a rest.

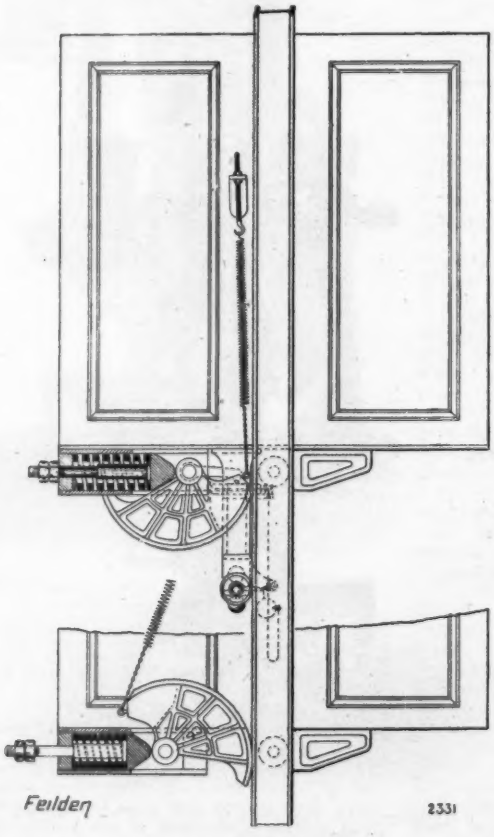


FIG. 1.—NEW AUTOMATIC LIFT BRAKE.

Messrs. Halket and Kennedy have carefully made experiments, at great expense, during the last two years, and their invention has at last reached the stage at which it can be introduced to public notice. In Fig. 1 the panneling represents the cage in elevation. There is a strong bracket beneath this carrying a cam, which is shown in two positions, the upper view showing it out of gear with the cage guide and the lower one in full gear.

It will be seen that the cam is acted on by a bolt with a shoulder pressing against its centre. A spring is fitted in pressing against the shoulder and keeping the cam forward towards the right. The right-hand corner of the cam is supported by a spring fastened at the other end well up in the cage. Further, the cam is so loaded that its centre of gravity is on the right-hand side of its centre. When, then, the cage begins to fall freely under gravity the cam and every thing attached to it loses weight. Now the weight of the cam balances the pull of the spring in the upper figure, and as soon as the cam becomes lighter the spring pulling upwards with the same force as before raises its side of the cam. The surface of the cam is furnished with teeth, and these gear in with corresponding teeth on the

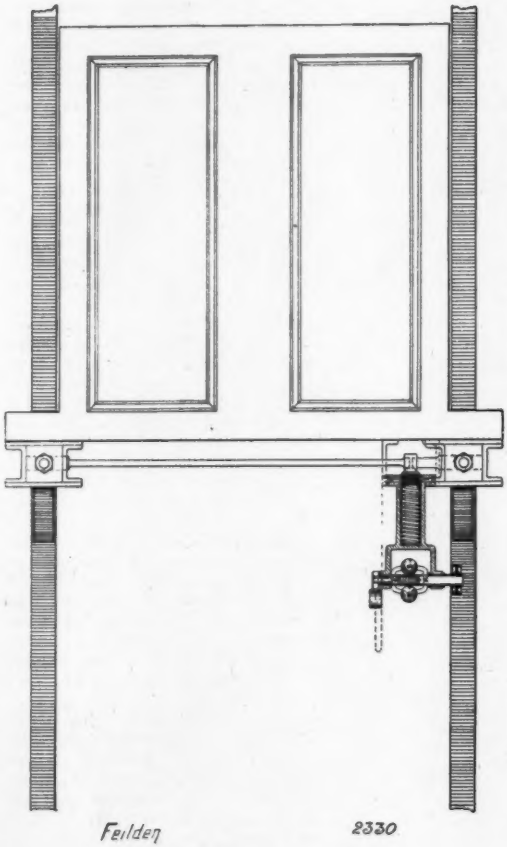


FIG. 2.—NEW AUTOMATIC SAFETY LIFT BRAKE.

side of the guide. As, then, the right-hand side of the cam is pulled with the spring it begins to gear with the teeth on the side of the guide, and, once in gear, it runs with it until it is brought to a standstill by means of a stop. It is in this condition in the lower drawing. Now as the cam runs in gear it pushes out the bolt against the spring, and this spring absorbs the energy of the cage and gradually brings the cage to a standstill.

Fig. 2 shows another method for bringing the cam into action. Here there is a small governor driven by a small wheel gearing in the rack on the side of the guide. When the governor moves quickly, the balls fly out, a pin is withdrawn from the lever on the left side, a weight is detached, and the cams are swung into gear.

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THE REPAIR OF THE SHAFT OF THE "FAZILKA."

IT is a serious matter when the propeller-shaft of a screw-steamer breaks in mid-ocean. The engineer is then flung on his resources, and it will depend entirely on his ingenuity and energy whether the ship will reach port by means of her own engines, or wait for the next steamer which comes in sight, to tug her there. Where another steamer has to be engaged, the owners of the damaged steamer are required to pay enormous damages, and the saving of these is thus an additional incentive to the engineer to do his best to repair the shaft and so bring the ship into port by means of her own engines.

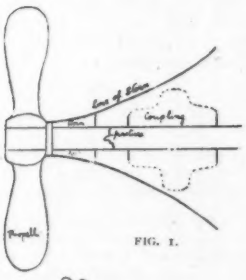

FIG. 1.

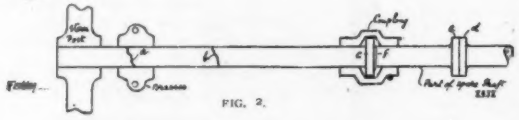

FIG. 2.

FIGS. 1 AND 2.—REPAIRING A PROPELLER-SHAFT IN MID-OCEAN.

Sometimes the fracture takes place in the crank-shaft, and when it does, there is little trouble or waste of time in repairing the damage done, for every steamer carries a spare one, and all that is required is for the engineer to replace the broken one by the spare shaft. There is danger though when the engines are of high-speed type; for the sudden breakage often causes some part of the engine to be injured, and this greatly complicates the trouble. When the line-shaft breaks it is mostly easily repaired, because couplings are carried in the ship to fasten on to the two broken ends. Should the fracture of one of the line-shafts be irregular, it is all the better; for the irregularity acts as a key to enable the one shaft to turn the other.

It was an awkward mishap when the tail-shaft of the *Fazilka* broke in mid-ocean. The fracture was so near to the stern-post, and the lines of the ship so close together at the place, that the ordinary coupling (Fig. 1) carried could not get near to the part of the shaft near the propeller to grip it. The engineer was thus thrown on his own resources to discover a method, and to use anything he could find about the ship to repair the shaft under those trying conditions.

But the case was even worse than that; for the shaft broke in two places, both at *a* and *b* (Fig. 2). The engineer had thus not only a joint to make near the stern-post, and in a confined position, but he had to make a second joint further back.

The crank-shaft rests on brasses, supported by the engine bed-plate, and the ship always carries a spare set of them. Each of these brasses embraces and bears on the shaft about half-way round, and so fits it closely. The engineer first took out the piece of shaft, between fracture *a* and fracture *b*, and then he pushed the shaft *b c* back against fracture *a*. After that, he took a pair of the spare shaft brasses, and placed in the shaft just at fracture *a*, as shown, and bolted the two firmly together, so gripping the two broken ends and making them so that one would not turn without the other. Thus was one fracture healed.

It will be seen that there would be left a space between flange *c* and flange *d*. There was another piece of spare shaft in the ship, on one end of which was a flange *e*. The engineer then cut the shaft at *f* so that it went in between flange *d* and *f*. After that he took a Thomson coupling, and placed it in the shaft embracing the ends *c* and *f*. The flanges *c* and *d* were bolted together, and the shaft was repaired.

Of course, this shaft was a serious case, and involved much trouble and time before it could be repaired. The face of *a* had to be squared by drilling and chipping. The face of *b* had to be treated in the same way, and it is not an easy matter cutting and squaring the end of an enormous propeller-shaft of 14 ins. diameter. Then the shaft *c f* had to be made of the proper length to fit in between the flanges *c* and *d*. Anyway, the work was finally done, and the ship brought to port by her own engines, and the great expense of salvage was saved to the owners.

G. H.

PRACTICAL ARTICLES FOR PRACTICAL MEN.

THE GAS ENGINE, BY JAMES HALL.

THE gas engine having taken such a prominent and permanent position as a producer of motive power in almost every branch of manufacture in which mechanical power is required, has induced the writer to put together a few practical notes which ought to be kept well under notice when an engine is being designed, erected, etc., and afterwards when being fixed in position.

When designing an engine:

(1st) The power required to be given off on the "brake," along with number of revolutions per minute of the flywheel, must be given, and also the probable candle-power of gas likely to be used by engine.

If "producer" gas is intended for use, this must certainly be brought before draughtsman's notice, as valves and cylinder are specially arranged when this gas is used.

The most popular class of engine now manufactured is, of course, that using the "Otto" or "Beau de Rochas" cycle, and all notes must be taken as bearing on this class of motor.

Having the above information to hand, the diameter of piston and stroke of engine can be fixed. These two particulars, along with revolutions per minute, are arranged to give a certain indicated h.p., which should not be less than 20 per cent. above the actual or brake h.p. required.

Using coal gas of 16 c.p., an average pressure on piston of 90 to 95 lbs. per sq. in. is assumed, using a compression of 70 lbs. to the sq. in. In cylinders under 7 in. and over 14 in. in diameter the above average piston working pressure is less and greater respectively.

A piston speed of 700 ft. per minute should not be exceeded; 600 ft. to 650 ft. give best results.

A very important item has now to be dealt with, *i.e.* the crank. Cranks put in engines ten years ago would be altogether too weak for a modern engine. Initial pressures on piston of from 320 to 350 lbs. per sq. in. have now to be dealt with, and spring in crank or connecting-rod is fatal to an engine. When a "bent" or forged crank is used, some makers allow $\frac{1}{2}$ in. in diameter of iron in crank-arms to every 1 in. in piston diameter. If this is followed out a good crank will result. When a square or machine crank is used, about 10 per cent. less sectional area of crank-arms is allowed owing to depth of "webs."

Diameter and width of crank-pin should be such that a pressure of from 1,000 to 1,200 lbs. per sq. in. is not exceeded, the area of pin being taken as diameter by width only.

It is a very important point that provision should be made for a constant and unlimited oil feed to crank-pin without having to stop engine. A very good and not very expensive method is that of the "banjo" lubricator, as shown in Fig. 1. *A* is a light brass ring fixed on crank-arm, and coupled to hole running to centre of crank-pin by pipe *B*

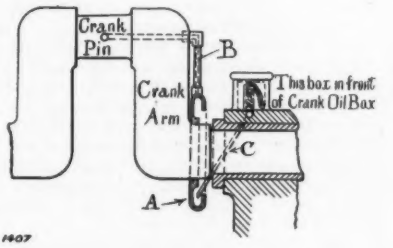

FIG. 1.
LUBRICATOR FOR CRANK PIN.

Oil is supplied from a lubricator on engine bed through tube *C*.

The connecting-rod should be made from 3 to $3\frac{1}{2}$ times stroke from *C* to *C*, and its diameter at large end should equal $\frac{3}{8}$ diameter of crank-pin, tapering down to piston end at about $\frac{1}{8}$ in. to the foot.

Piston should not be shorter than stroke of engine if smooth running is required.

Narrow spring rings of cast-iron are now most in general use; five rings $\frac{3}{8}$ in. wide give good results on engines up to 10 in. cylinders. More rings are used on larger diameters.

The two most popular methods of building pistons are shown by Figs. 2 and 3.

Fig. 2 shows section through a "solid" piston, grooves being simply turned in piston

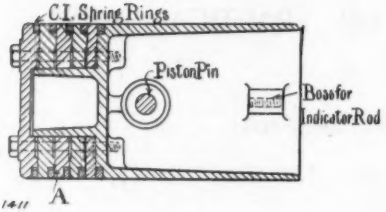

FIG. 2.

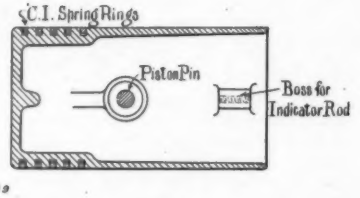

FIG. 3.
METHODS OF CONSTRUCTING PISTON.

body and spring rings let in. It owes its popularity chiefly to cheapness of manufacture and lightness of running.

Fig. 3 shows class of piston used by some makers on all engines and by nearly all makers on engines of large cylinder diameter. It is a more expensive one to build. It has one great advantage—the junk rings *A* can be turned up and adjusted to standard width whenever it is necessary. In "solid" pistons, when grooves are worn, it is necessary to widen them in facing down sides, causing rings of special width to be let in.

In arranging cylinder and liner, care should be taken to allow sufficient water-jacket space around liner.

Bad circulation and consequent overheating are very often the result of cramped water space.

In dealing with the valves too much attention cannot be paid to them. Both air and gas valves must be made so that the gases can flow freely into the cylinder, when required, long and tortuous passages must be carefully avoided. In small engines it is preferable to couple air-valve with a chamber in bed of engine, both for silencing air suction and keeping foreign matter from cylinder.

The exhaust valve must be of ample dimensions and water-jacketed. The writer has seen many valves which have not been so constructed, and which have been a constant source of trouble, causing spindle-sticking, premature ignition, &c. The area of exhaust valve seating should not be less than one-ninth that of the piston. The area of air-valve is generally about one-tenth that of piston, and area of gas-valve about one-third that of air-valve.

Before leaving the valves let one very important point be mentioned.

The best results have been obtained from engines with both the air and exhaust valve spindles arranged to open direct into the combustion or compression space in cylinder, no passages at all being exposed to the action of the gases in cylinder during combustion.

Ignition or timing valves should certainly be arranged on all engines above 10 b.h.p., and on engines for electric lighting purposes two sets should be arranged, so that in the event of one tube failing the other can be put into use immediately.

When the engine is going to work by "Producer" or "Dowson" gas, the area of passages and valve for gas should be made four times as large as when coal gas is used.

The area of cylinder must also be increased about one-fourth to give equal power, and a compression used of about 90 lbs. per sq. in.

A convenient way of arranging for valves to open in compression space, or even cylinder itself, is shown by Fig. 4.

A long "nose," *A*, is cast on body of valve (air-valve in sketch), and on which the valve is seated. The edge of "nose" is "mitred," as shown, to form a joint in cylinder casting. Clearance must be allowed at *B* to ensure valve being hard on joint.

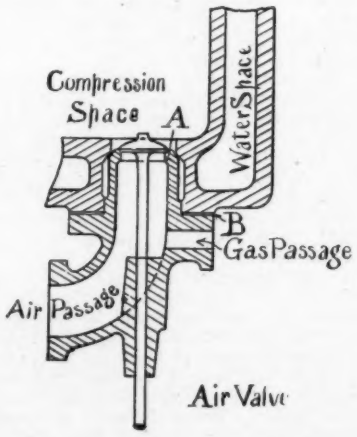

FIG. 4.—METHOD OF ARRANGING INLET VALVES.

If skew gear and side shaft are used for working valve cams, the lower wheel should always revolve in an oil bath. It is generally found most convenient to arrange for this in wheel guard itself.

Fig. 5 illustrates a guard in two parts, the lower part carrying sufficient oil to cover wheel teeth.

In dealing with the flywheels of an engine it may be pointed out that many engines now on the market are spoiled through the bad designing of their wheels.

There seems to be a great desire on the part of many makers to put a wheel of small diameter but of very heavy section on their engines. If larger diameter wheels were used (providing a rim velocity of from 70 to 75 ft. per second is not exceeded) a wheel of considerably lighter section would suffice, would consequently reduce friction of engine, and, last but not least, cause much steadier running.

Most Continental makers are now using wheels of large diameter and light section very successfully.

All engines should be balanced. The best method of balancing is that of attaching weight on crank webs similar to the manner in which locomotive cranks are balanced. Perhaps the next best method is that of attaching weight in flywheel arms at the same radius as the crank-pin. Rim balance in flywheel is not as reliable as either of the above, being only correct for one fixed speed.

As a summary of this section of an engineer's work when about to build an engine, see that all materials ordered are of first-class quality. Bearings of ample length and diameter, and that no unduly heavy pieces of metal are cast in cylinder or bed, causing nasty strains to be set up, and thereby being a source of weakness and danger.

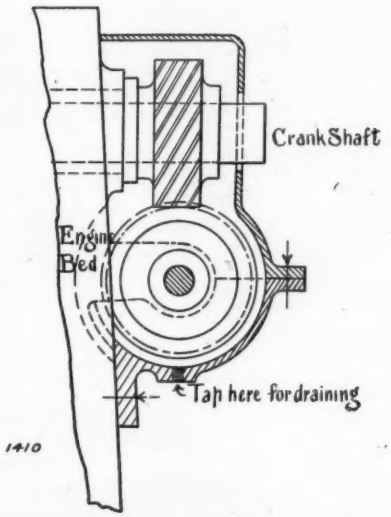

FIG. 5.—ARRANGEMENT FOR LUBRICATING SKEW GEAR.

FITTING AND ERECTION.

The engine bed is usually the first part dealt with, and the bottom of which should

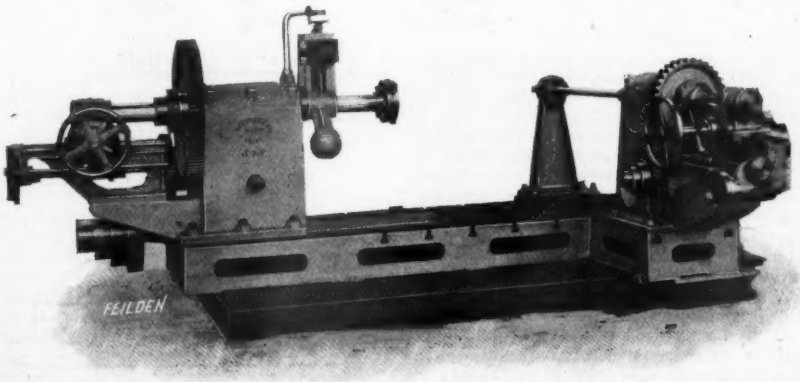

FIG. 6.—TOOL FOR MACHINING GAS ENGINE BEDS AND BORING OUT CRANK BEARINGS.

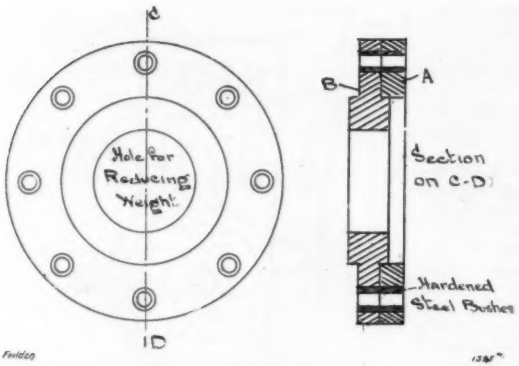

FIG. 7.—JIG FOR DRILLING BOLT HOLES IN CYLINDER.

be planed. This is well worth the trouble, for rapid setting of same on boring machine, and again when running on beds in testing shop.

Crank cap guides are best machined out on a side planing machine. Special care is required in setting bed on boring machine table, so that crank bearing shall be bored out square with facing for receiving cylinder, if they are not so there is always a tendency of crank shaft to "travel," and so give trouble.

A special and very useful tool for machining beds on cylinder facing, and which also bores out crank bearings at the same time, is manufactured by Messrs. Buckton, of Leeds, and a view of which is shown in Fig. 6, and the following particulars of which may be of interest.

The main bearing and facing headstock can be traversed along the bed so as to deal with different sizes of engine, and in addition to the boring spindle, carries a compound arbour rest for facing and turning cylinder seats. The cross-boring head is driven independently from the main headstock. An outboard bearing is provided for boring bar, as it has to span two bearings. One great advantage in using this class of machine is that the crank bearing is always bored square with the cylinder.

Wherever possible, it is of great advantage to drill holes, etc., from jigs.

A very handy form of jig for drilling bolt-holes in cylinder and bed is shown in Fig. 7. Part marked *A* slides on nose of liner after it is let in cylinder, whilst part *B* fits in bored end of bed.

Ordinary U gauges are sufficient for giving widths of crank bearings, and a standard bar gauge should be kept for widths between. These two particulars refer to machined *C I* parts on bed. The brasses for receiving crank shaft should be let into their places, or carefully made to bar gauge fitting before-mentioned U gauge.

In machining cylinders, gauges or templates should be used for boring end to receive liner, and also for making seating for same, at top end of cylinder. A template cut from a piece of ¼-in. steel plate (or built up), as shown in Fig. 8, is often made to answer for both facings.

Another machine, built specially for dealing with gas engine liners and cylinders, has also been put on the market by Messrs. Buckton, and a view of which is shown by Fig. 9.

As will be seen, it is a duplex snout boring machine. There are two independent tables to which work is secured, which enables one cylinder or liner to be proceeding whilst another is being set on table. The "snouts" on machine are of very stiff proportions, and are provided with conical bearings at their front ends. One very great

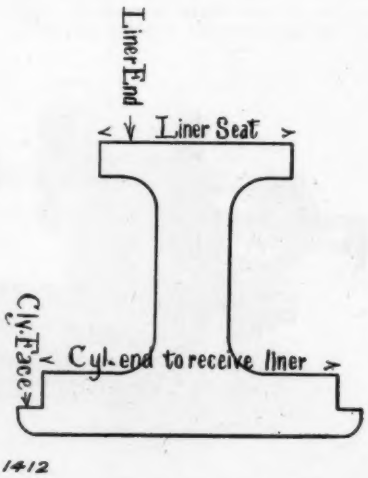

FIG. 8.—TEMPLATE FOR LINER SEATING.

advantage in using this machine is that the work can be placed on the tables and taken off again very much quicker than when a boring bar is used. Further, there is not the same liability for "spring" taking place, as the boring head is close up to its bearing. The machine is spoken of by users as being a valuable tool.

When cylinders have "nosed" valves fitting into them, dummy valves, or even a "nose" with similar flange on to valve, should be supplied to cylinder borer as a template, see Fig. 10 (illustrated in our next issue).

All valves should be carefully examined after holes are bored for spindle bearings.

A short bed, carrying a self-acting boring headstock, is also arranged, so that wheel may be bored and boss forced, etc., whilst rim is being turned.

The faceplate is fitted with four adjustable jaws, as can be seen, for chucking wheel internally.

If skew gear is used on engine, it should always be cut. Of course "spaced blanks" are very often cast and then cleaned out on cutting machine.

Pistons should be brought to template or gauge on grinding machine, to ensure a good job.

If junk rings are used they are best turned about $\frac{1}{32}$ in. less in diameter than liner

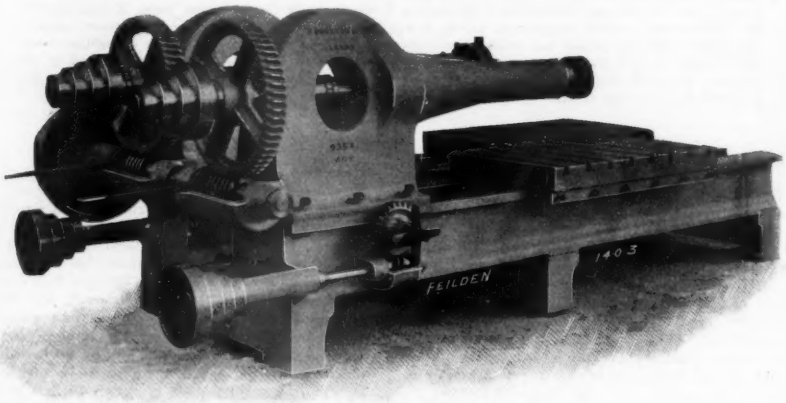

FIG. 9.—DUPLEX SNOUT BORING MACHINE FOR GAS ENGINE CYLINDERS.

Valve castings which show blown holes after boring should be rejected.

A set of templates for all valves are always necessary if constant adjustment of lever bosses, etc., is to be avoided. It is not much advantage to "chamber" flywheel bosses, as it is a difficult matter to bore them perfectly true if they are chambered.

A very necessary tool is shown in Fig. 11 (illustrated in our next issue) for the production of flywheels at low cost, and which is manufactured by Messrs. Smith & Coventry, of Manchester. It is a treble-geared flywheel lathe for turning and boring wheels up to 6 ft. in diameter. It has one rest for turning face of wheel, either flat or to any desired curve, and another double slide rest for turning both edges of the rim simultaneously.

bore; they are liable to "seize" when engine is running if this is not done, owing to the high temperature to which those nearest the combustion chamber are subjected, and their consequent expansion being greater than that of the liner, the latter being in contact with circulating water.

JAMES HALL.

(To be concluded.)

Some of the world's greatest experts in every branch of industrial activity and scientific research are writing special articles for forthcoming issues of - - - - - - FEILDEN'S MAGAZINE.

WORKSHOP PRACTICE

The purport of this section of FEILDEN'S MAGAZINE is to give the skilled mechanic in our great industrial establishments an opportunity of bringing his practical ideas and experience into print. Inventive capacity and careful thought on the part of the workman is what we desire to encourage and foster. To this end we invite skilled mechanics, foremen, under-foremen, and heads of departments, to communicate practical suggestions, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice, as, when draughtsmanship is at fault, we will do all that is necessary to render them fit for publication. Nothing will be too poor for a careful inspection. Questions relating to shop practice are also invited, for which we pay one shilling. Answers to these questions that are printed are also suitably paid for according to merit.

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Drilling a Square Hole.—The operation of making a square hole of given depth is sometimes a rather difficult job, or occupies more time than is convenient. The usual practice is to drill down to the required depth and then square out with a chisel or drift. The illustration shows a method whereby a square hole may be produced either in the lathe or drilling machine by the following arrangement. The piece *A* is required with a square hole in the end, and is one of a number made out of stock bar on a turret lathe; it is shown in position in the screwed chuck *C*. A collar, *D*, having an internal thread behind, and a square hole, *E*, at the front of the exact size required, is tightened against the front end of *A*. The drill or cutter is formed of a piece of steel of triangular section—if used in the lathe—or with a round shank to suit drill chuck; each side of the triangle coincides with the sides of the square, *B*, required, the cutting edges being formed by milling or filing, and afterwards hardening. The cutter is shown at Fig. 2 as arranged for lathe or drill, the centre at end providing for entrance of lathe centre for feeding up. When used in drilling-machine the tool is held in a "floating" chuck having a lateral movement which allows the drill to follow a square hole cut in a guide plate about ⅜ in. thick, which is then fastened on the top of the work.

JOBIC.

Double-Throw Crank Turning.—The turning of wrought-iron cranks having two or more throws is an operation of some importance, and by the following methods a good reliable job may be produced. This form of crank varies in size, from that of a small pair of engines to the enormous sizes used in marine work. The forging, as shown at Fig. 1, should be reduced by a roughing cut to within ¼ in. or ⅜ in. of the finished diameters; the slabs, *S*, should then be planed to the proper thickness, and care taken that they are in strict relation to each other, as 90 degs. for a double crank, 60 degs. for three-throw, etc. The metal indicated by the dotted lines on *S* is then removed, either by band sawing into a couple of holes previously drilled through the slab, or by a slotting machine, leaving the connection to be turned up to a journal. The shaft is then returned to the lathe, and stays should be placed in the openings to prevent springing, while the parts, *A*, *B*, *C* (Fig. 2), are finished. The fixing for turning the journals is shown at Fig. 3, and consists of an iron casting, bored in some cases to a shrinking fit, and sometimes held in position by a saddle-key. On the flat side of this casting the positions of the journals are set with the proper amount of throw and relative position, and for the purpose of providing better centres screwed steel plugs, counter-sunk to suit the lathe centres and hardened, should be inserted in the fixing. Instead of the triangular casting a circular plate may be used to advantage at times, as the increase of surface provides for a greater number of throws or other variations. Strong roughing-out tools must be used, the finishing being generally done with a spring tool, well lubricated with soap and water.

J. GREEN.

[NOTE.—Modern practice is to turn the journals of the cranks with a tool carried in a rest, specially designed to travel round the periphery of the journal.—ED.]

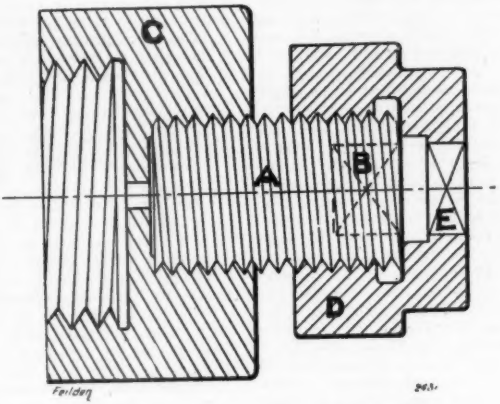


FIG. 1.—METHOD OF DRILLING A SQUARE HOLE.

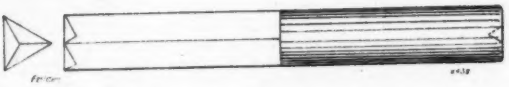
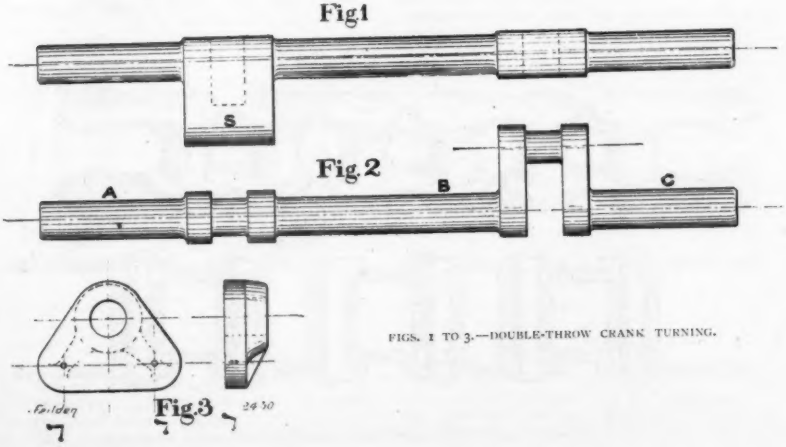


FIG. 2.—DRILL FOR CUTTING A SQUARE HOLE.



FIGS. 1 TO 3.—DOUBLE-THROW CRANK TURNING.

The Making of Cycle Chains.—The impetus given to the cycle trade by the immense number who participate in the recreation of cycling, has not only increased the number of makers, but has brought out all the several points of importance, and has gradually developed—by means of competition—the best systems of manufacture with the most approved designs, so that it may be said of a high-grade machine, that scarcely anything remains to be done by way of improvement. Among the many parts that go to make up a complete machine, perhaps one of the principal factors is the chain used on the ordinary type of safety, and in the present article it is intended to show the evolution of the same, and the methods of producing this prominent accessory, as it is manufactured by modern machinery in an up-to-date shop — electrically driven and lighted, equipped with special automatic and labour-saving tools—for the making of the different kinds of single and twin roller, block and other chains. The several processes will be taken seriatim, from the first operation on the raw material to the final stage, when it is placed in the stock room for exportation.

When the high bicycle was superseded by the safety, and chains were first applied to the old style of tricycle, the early type of chain was of the same kind as that used on the carding engines of the Lancashire cotton mills, but this was after some little time found to be defective, owing to the stretching consequent upon such an increase of speed compared to the slower motion of the cotton machinery. This chain consisted of three parts, viz., the inside and outside links, the pivot, and the roller. Some of the difficulties connected with this particular chain was the wear, consequent upon the short bearing given to the inner link and the tendency of the riveting to tighten the chain, caused by the expansion of the ends of the pivot when riveted, thus leaving only the inside links free to move on the pivot when travelling round the wheel. This gave an undesirable rigidity to the chain, with an excessive amount of wear on the inside joints when only a moderate speed was attained, and by reference to Fig. 1 it will be seen how the links bedded themselves into the pivots and the chain became elongated thereby, thus destroying the correct pitch in relation to the driving and hub wheels. A further advance then took place by the introduction of a *thicker inner link*, which would give a greater wearing surface and reduce the cutting action on the pivots, but this was found objectionable on account of the increased weight.

A further improvement was then brought forward, and which consisted of *a bushed link*, through which passed *a shouldered pivot*, and with *a loose bush* revolving on the fixed one, and free to move round the curves of the wheel teeth. The pitch of this chain had also been doubled in order to fit the same wheel teeth *alternately*, with the object of reducing the weight and minimising the wear, the shouldered pivots, when riveted, preventing any possibility of the several parts becoming detached. The four separate parts, viz., the link, shouldered bush, revolving bush, and pivot, are shown (Figs. 2, 3, and 4) at different stages, but without reference to actual sizes.

A different but very effective form of chain, contemporary with the last described, and known as the block chain, consisted of steel blocks of figure eight section, held together by outside links and shouldered pivots, was introduced with the object of giving a strong yet light chain with a maximum amount of bearing surface, as the blocks coincided with the tooth space, giving the full amount of contact.

The latest developed and up-to-date chains are known as the *short pitch* and *twin roller*, both of which have distinctive advantages. These are made up of outside links, shouldered pivots, and an inner and outer bush, both of which are free to revolve the one on the other, and both on the pivot; with this arrangement of parts, we may be said to have reached the present-day stage of cycle chain, its transition having occupied a period of nearly twenty years.

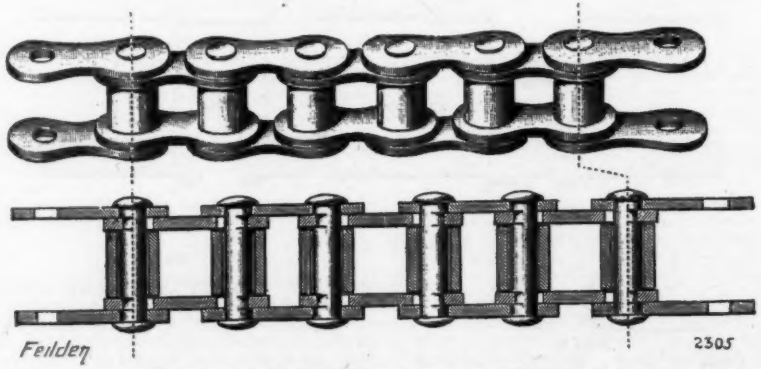


FIG. 1.—CYCLE CHAIN, SHOWING ELONGATION DUE TO LINKS BEDDING IN PIVOTS.

We must now turn to the more interesting subject of manufacture, and ask our readers to accompany us into a region where the standard inch is divided, and measurements are conducted

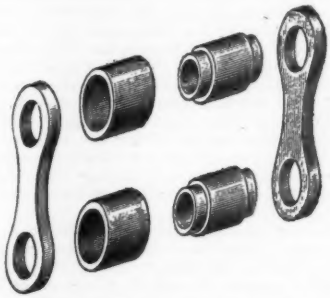


FIG. 2.—CYCLE CHAIN LINK PARTS BEFORE BEING PUT TOGETHER.

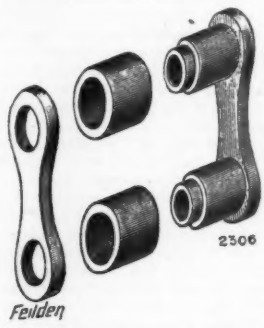


FIG. 3.—CYCLE CHAIN LINKS PARTLY PUT TOGETHER.

FIG. 4.—CYCLE CHAIN LINKS RIVETED UP COMPLETE.

FIG. 5.—ANOTHER VIEW OF LINK.

to the fraction of a thousandth, and where the neglect or error of an infinitesimal amount would render a mass of material useless.

The initial stage of a cycle chain consists of the blanking of the links out of strips of steel, rolled to the required thickness with a variation allowance of only the *thousandth of an inch* above or below the specified gauge. The strips are supplied from the rolling mill in lengths of about seven or eight feet, and are of high-class steel containing not less than ·05 per cent. of carbon, and capable of standing a tensile strain of 45 to 50, and even as high in some special mixings as 90 tons to the square inch. On arrival at the works, the steel is accurately gauged by a machine which registers to the $\frac{1}{1000}$ of an inch, and should the test show a greater variation than the amount previously mentioned they are at once rejected. Pieces are also taken indiscriminately from the several bundles for the tensile test, and only a very small percentage of variation is allowed in this case. The selected steel is then passed on to the workmen who operate the blanking or punching machines, and who from long practice are capable of "blanking" from 3,000 to 3,500 links per hour. The links are then taken away from the blankers to be "wet scoured," a process performed by placing them in revolving metal barrels fixed on the ends of shafts, and partially filled with a mixture of water and other substances. The links continually change position by coming in contact with strips of metal set in the barrel, which have the effect of momentarily retarding them during the revolutions. The falling by gravitation, and the eroding effect of the mixture, produces sufficient friction to remove the slight burrs left on the edges after the blanking. For purposes of economy, two or more of these cylinders are driven by a single belt, but a mechanical arrangement is provided by which any one of them may be independently thrown out of gear, tilted, and emptied, at the same time leaving the others working or ready to be filled with a further supply of the same or other work. Another feature is that the temperature of the liquid leaves them sufficiently dry when taken from a sieve into which they have been tipped, to be immediately ready for the next process, that of "setting-up." This operation places the links in rows, edgewise, to enable them to be more easily supplied to the shoot or hopper connected with the drop hammer, under the dies of which each individual link is pushed by an automatic arrangement, which at the same moment releases the hammer, and, falling on the link, already in position, "chamfers" or bevels the edges of each one exactly alike, the object being to give an appearance of lightness to the link, without detracting from its strength, and to assist the entrance of the wheel tooth. The links are then passed on for the next operation of "holeing," which is performed on similar machines to those used for blanking; both holes are punched simultaneously by punches set in a block, which in turn is fixed in the ram or vertical slide of the machine. These punches are provided with eccentric necks, which permit of very minute adjustment, and must exactly coincide with the die into which they enter. The position of the punches is perhaps one of the most important points, as any variation makes the chain too long

or too short in pitch over all, or would produce a twisted appearance in the length. The holeing process necessitates a second churning or "jingling," after which they are sent for inspection, to be passed by those under whose practised eye all the slight imperfections are at once detected. The links passed as correct are then prepared for the next process by threading a great number of them on double wires, which accurately fit the holes for the purpose of "glazing," which removes the knife-edge produced by the chamfering, and is done on special emery wheels revolving at a high rate of speed, and the contour of which is suited to each special form of link.

The next and final stage is the colouring or "blueing," which is performed by revolving the links in large iron pans fixed on the ends of shafts similar in design to those used for "scouring," but with the difference that they are heated by a double jet of gas, to which is added the proper quantity of air supplied by a small fan, which at the same time forces the mixture through the burners, the front of the barrel being closed with a tight-fitting lid. Here again comes the expert, who from long usage can tell just the right moment when to shut off the heat and tilt the contents of the pans into a portable tank filled with "Cosmoline," which tempers them and fixes the colour. The next important parts are the rollers and bushes, both of which are identical in appearance, but varying in length and diameter, the external diameter of the bush coinciding with the internal diameter of the roller. Both of these parts are turned out of bar steel by automatic machinery of the most approved type, and capable of very fine adjustment, the surprising accuracy of the repetition work leaving less than one per cent. of rejected rollers or bushes on an output of something like 130 per hour, and with a diameter variation of not more than the $\frac{1}{1000}$ of an inch; as a further check, a daily record chart is kept of the performance of each machine in reference to diametral and longitudinal variation.

The rollers and bushes are then passed on to the automatic coning machines, where they are fed into a shoot communicating with a slide which carries them into dies where they are held and operated upon simultaneously at each end, to remove the slight burr caused by the boring and parting-off tools in the process of turning. They are now inspected and sorted, in order that those which are above the size, may be used alternately with those under the size, and also for the purpose of seeing that the coning of each one is concentric with the bore. The next operation is the hardening; this process is performed in special furnaces heated by gas, the supply of which can be regulated to a nicety, thereby ensuring an even degree of temperature. The rollers and bushes are placed in cast-iron pots of special form, which allows the heat to play over the entire surface, and bringing the contents up to one uniform degree. The pots are of different design, to suit the several classes of work, and are fitted with lids which are luted with clay, by means of which the work is protected until the exact moment arrives for lifting out the pots, raising the lids, and tipping the contents into tanks to harden. The hardening is another of those delicate processes that depends almost entirely upon the judgment of the operator to determine just when they must be plunged in the hardening tanks; further, it is an operation which has cost a very great amount of research and experiment to make it a commercial success, as the method of procedure is one that, if it were not carried out in a proper manner, would mean the spoiling of the most costly parts of the chain, the reduction of the tensile strength, and the deterioration of the metal, as no two grades of steel can be treated exactly alike. The slight amount of expansion or contraction attendant upon this operation necessitates a re-gauging of the bushes and rollers, which are sorted into their respective places for future use.

We now pass on to the next piece, which completes the number of chain parts, viz., the stud or rivet, which passes through the bush, and the ends of which protrude through the outside of the links.

The first process to which the studs are submitted is "cropping-off" or shearing the coil of wire into short lengths, something longer than the finished stud. This operation is performed on machines which are capable of shearing about 5,000 per hour, the wire passing through revolving dies which straighten it to such a degree that there is no appreciable bend or curve in the lengths intended for the studs. The cropping-off, however, leaves the pieces with a slight burr upon them, which is removed by "jingling," after which they are passed on to the stud machines, where from a hopper, and by another form of automatic slide, they are pushed into the jaws of a vertical vice, forming part of the machine in which they are located, and securely held, when cutters, carried on the end of spindles, proceed simultaneously to turn down each end of the piece to the fixed diameter. The whole of the movements on these machines are automatic and economical; the cutter spindles are arranged with a quick return motion on the completion of the cut, to again attack—after a momentary pause—another piece which is pushed into position during this brief period. The beautiful precision of the whole mechanism is due to a continuous study of the work required to be done, and an insatiable desire to make it perfect; apparently there is neither pains nor money spared to enhance its productive powers or secure its faultless working. In connection with the studs, the same processes are again gone through, viz., the inspection before and after hardening, the scouring to remove the slight burrs formed upon them, then afterwards the dry jingling which polishes them brightly all over, yet with such a slight reduction that no variation in size can be detected.

So far we have dealt with the making of the chain parts, and we shall now see how these are assembled and put together to form the chain ready to be slipped on the machine by either the maker or cyclist A given quantity of the accurately gauged and inspected material, in the form of links, bushes, rollers, and studs, are sent to the making-up room, where

there are a number of machines which are operated by females, who take the respective parts in turn from the trays, and first placing the link in a die, the outside rollers on the top of the link, then the bush inside the rollers, completing the operation with another link on top, which then forms a complete link minus the stud, as shown at Fig. 3. At this stage they are taken to another machine similar in action, but provided with a different arrangement of die, this one having two small holes, which coincide with the pitch of chain. Here the outer link, having holes punched to the exact diameter of the stud neck, is placed in position, and a couple of the pieces (as shown at Fig. 3) are placed at each end of the underlying link; a stud is fixed in each end, and covered with another outer link. The press ram is then brought down by means of a treadle, another one opening and closing the jaws of the vice, which hold the chain parts in their relative positions. This completes the operation of what may be termed the building up of the chain, and in this condition they are now passed on to the riveters, who place them on a table provided with a large machine-cut toothed wheel fixed on a centre, the pitch of which corresponds to that of the chain. The built-up chain encircles the wheel, and the slightest variation in pitch over the entire length of chain is at once detected. In the earlier type of chain, the studs were left as supplied off the coil, and, being moderately soft, were machine riveted. This operation was performed by a hardened steel cup, fixed in a chuck carried on the end of a vertical spindle, having a rapid double movement acting simultaneously in a rotary and vertical direction; a similar cup fixed in the machine table formed the anvil, and received the opposite end of the stud. The table was gradually raised by a foot lever, both hands of the operator being free to guide the chain into position. The top riveting cup not only spread the end of the stud, but formed a finished head. This was accomplished by the cup having slight cutting edges, which trimmed the head to shape. It was eventually found necessary to harden the studs, in order to give them a wearing surface equal to the hardened bushes. By the hardening of the studs, machine riveting was rendered impracticable, as the blows given by the ram were too sudden, and splintered the ends of the hard studs, with the result that machine-riveting has been superseded by hand work on the best quality of chain. This operation, like many of the preceding ones, is the work of specially trained operatives, who from long practice can judge to a nicety the exact amount of force required to expand the end of the stud, and which is facilitated by the slight cone or countersink formed at each end.

From the riveters, they are now taken to the "stretching" machine, where each chain is subjected to a tensile strain of 1,600 lbs., an amount of tension which quickly discovers any weak part by breaking before elongation begins. This last factor provides another check, for should the chain show an extension of more than ·00625 inch per foot it would be at once rejected. The comparative lightness ($\frac{3}{4}$ lb.) of an ordinary length of chain—about four feet—is remarkable when we consider that it is composed of nearly 500 distinct pieces.

The final stage is now reached, when they are subjected to a process called "whizzing," the placing of the chains in a rapidly revolving pan, into which is poured a quantity of special oil. The centrifugal force spreads the liquid over the chain, and is carried to the periphery of the pan into a spout, where it is collected to be used many times over. By this operation every drop of superfluous oil is drained away, leaving the chain now ready for the machine, the ends being connected by a small stud and nut.

From the description given in detail, of the evolution and construction of cycle chains, some conclusions may be formed as to what are the essential characteristics connected with rapid and remunerative production, and they may be defined as follows:—

(*a*) Constant supervision and the testing, at short intervals, each and every part as produced.

(*b*) Frequent changing of the machinery and equipment to keep abreast of competition.

(*c*) Perfect sanitary arrangements, good light and well ventilated workshops, conducive to accuracy.

(*d*) Specially trained labour, receiving satisfactory wages.

With a strict vigilance in support of these *existing* conditions, it may be said that cycle chain making has become one of the representative British industries of the present century.

W. H. Wilson.

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INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

CIVIL ENGINEERING.

A New Steel Arch Bridge across Niagara River.—The old suspension bridge crossing the Niagara River between Niagara Falls and Clifton, erected by Mr. Samuel Keefer, and subsequently widened and rebuilt by Mr. Leffert Lefferts Buck, M. Inst. C. E., has since been superseded by a steel arch bridge, also constructed by Mr. Buck, in order to provide a suitable passage for the constantly increasing traffic and a line of electric trolley cars. Its site is about 300 yds. below the American Fall, and about three-quarters of a-mile below the great Horseshoe Fall on the Canadian side. Mr. Buck recently described the details of his interesting work and the progress of construction in a paper read before the Institution of Civil Engineers. As the river, at the site of the bridge, is 180 ft. deep, and has a current of between four and five miles per hour, false work was, of course, out of question. Notwithstanding the large span of the new bridge, it was calculated that not only would it cost considerably less than widening and strengthening the suspension bridge sufficiently to accommodate the increased traffic, but the new bridge would be stiffer and stronger than the renovated old bridge. For several reasons it was decided to brace the ribs instead of the spandrels, though the latter were employed wherever feasible. The new bridge has a main span of 840 ft., and two end spans, one of 190 ft. and the second of 210 ft. The main span is a two-hinged parabolic braced-rib arch, supporting the floor-system by means of vertical bents resting on the top chords of the arch at the main panel-points; the end spans are pin-connected inverted bow-string girders. The material from which the bridge is constructed is basic open-hearth steel, required to have an ultimate tensile strength of 62,000 lbs. to 68,000 lbs. per square inch, an elastic limit of at least 20 per cent. on an original length of 8 ins. The bridge carries on one level two lines of trolley-car tracks, two carriage-ways outside the car-tracks, and two side-walks. The floor is 8 ft. 6 ins. lower at the Canadian side than at the New York side. For the abutment 1,417 cub. yds. of concrete and 220 cub. yds. of masonry were required; the small amount of masonry needed showing the natural advantages of the site for an arch bridge. The abutments on the New York side rested on solid sandstone rock, and it was expected that the foundations on the Canadian side would be similar, but excavation showed the material underneath the abutments to consist of boulders, ranging from pebbles to blocks several cubic yards in size, closely imbedded in a matrix of gravel. On this material foundations of concrete were built, with flaring sides to give ample base, extending back to the vertical face of the solid rock. The factors of safety throughout were large, the abutments being built with a view to providing for an increase of 25 per cent. in the loading, should it become desirable to increase the capacity of the superstructure in the future.

The New Panama Canal Project.—On the 5th of last month Mr. J. T. Ford, M. Inst. C. E., read an extremely interesting paper, entitled "The Present Condition and Prospects of the Panama Canal Works," at the ordinary meeting of the Institution of Civil Engineers. From this paper it appears that the works are in far better condition than is generally supposed, even the maritime sea-level sections, which are most exposed to tidal and flood damages, having suffered but little. Of course, a considerable amount of new plant will be required, but there has remained much that is still serviceable, as is shown by the work accomplished by the New Canal Company. Referring to the inherent difficulties to be encountered in the construction of any canal at Panama, whether at sea-level or with locks, the author expressed the opinion that, although a sea-level canal would be, of course, very costly, it was quite feasible, and would certainly be the ideal solution of the problem. The three main difficulties in constructing a canal at Panama are apparently: the question of water-supply for lockage purposes during dry seasons; the control of the Chagres River during its flood seasons; and the nature of the material encountered at the great cuts of Culebra and Emperador. After a careful and thorough examination of these difficulties by actual experimental work under practical conditions, a favourable solution of all of these was found to be possible by three equally feasible projects for a lock-canal submitted to the company, *i.e.*, one of them with a summit level of 126 ft., a second with a level at 98 ft., and a third at 62 ft. above sea-level. Of these the medium plan with a 98-ft. level was recommended, but the author himself differs from the view of the Commission,

and is strongly in favour of the level at 62 ft. above sea. Assuming that the plan recommended by the Commission is to be carried out, and taking into account the general work done already, the author expresses the view that what has been so far accomplished fairly represents a sum half of what will ultimately be the total cost according to the estimate of the Technical Commission, and that the remaining work will require from eight to ten years, so that, in spite of the admitted extravagance and errors of the old company, it may be said that one half of the total work required is already done. The remaining half will, according to the estimates of the Technical Commission, require a further sum of £20,816,000.

Rebuilding of Glasgow Bridge.—At a meeting of the Institution of Civil Engineers last December, Mr. Benjamin Hall Blyth, M.A., M.Inst.C.E., read a paper dealing with the taking-down and rebuilding of the bridge over the Clyde, at the Broomielaw, Glasgow, constructed by Telford in 1833. He mentioned the reasons which induced the corporation of Glasgow to obtain, in 1882, an Act of Parliament for the construction of a new bridge of four spans, and later, in 1894, to obtain another Act, repealing the former and authorising a bridge to be built which, while considerably increasing the width and strengthening the foundations, still preserved Telford's original elevation. The bridge, as rebuilt, consisted of seven spans varying between 52 ft. and 58 ft. 10 ins. Each of the piers was carried by four 15-ft. cylinders, which were sunk by means of pneumatic pressure to a depth of 75 ft. below springing-level. Centering was provided for all the seven arches, and all the arches were completed before any of the centres were struck. The piers were of freestone masonry faced with granite, and the arch-stones were granite throughout. Provision was made for gas, water, and electric mains under the pavements. The work was begun in 1895, and completed and opened for traffic on the 24th May, 1899.

Civil Engineering Projects in Formosa.—According to a recent report of H.M. Consul for South Formosa there appear to be important openings for the investment of foreign capital. Foreign manufacturers desirous of obtaining Formosan Government general orders for the supply of materials are advised to appoint an agent in the island to obtain early information of proposed new works and to push their interests, and they should furnish him with plans, specifications, and prices, so as to place him in a position to put in a complete tender at short notice. The following public works are now in progress or contemplated in the island:—A railway from south to north (28,000,000 yen, from 1899 to 1908); a cross railway from east to west in the south central district; harbour works at Takou; dredging works at Aupiny; waterworks at Takou; lighthouses (106,667 yen, North Island, Pescadores); and telegraphs (124,744 yen). These figures are taken from the "Formosan Budget Estimates" of the current financial year (1900-1), and most of the contracts have already been disposed of, though there are still many chances for enterprising engineering firms.

A Queensland Railway Bridge.—An interesting railway bridge over the Fitzroy River, connecting the central railway system of Queensland with the deep-water port of Broadmount, was described in a paper, read by Mr. Walter James Deak, B.E., Assoc.M.Inst.C.E., at a meeting of the Institution of Civil Engineers last December. This bridge carries a double line of way of 3 ft. 6 ins. gauge, and consists of two 250-ft. spans and three 100-ft. spans. The open-caisson method was adopted for sinking piers Nos. 1 and 2 in the river-bed, piers Nos. 3 and 4 being on land. The caissons were of wrought iron with straight sides and semi-circular ends. The framework of channel and T-bars was covered with buckle plates, 4 ft. square, wherever possible, and with plain plating elsewhere. The excavation for sinking was carried out by divers, as were also the concreting operations. . . . For the 250-ft. spans, a hog-back Linville truss was adopted, the curve of the top boom having a radius of approximately 538 ft. The depth of girder at the ends was 16 ft. 6 ins., and at the centre, 30 ft. 9 ins. The web-bracing consisted of a double system of vertical posts and inclined ties. The cross-girders were suspended to the lower ends of the vertical posts by tongue plates. The main girders were 26 ft. apart from centre to centre. The deck was of the American type, the rails being laid on ironbark sleepers carried by steel longitudinals, riveted at the ends to the webs of the cross-girders. Upper and lower lateral bracings and vertical sway-bracings were provided, also heavy portal-bracings. The 100-ft. spans were carried by simple rectangular Linville trusses, 16 ft. 6 ins. deep, with a single system of web-bracing panels. A footway, 5 ft. wide, was provided on the downstream side, carried by a light latticed parapet-girder resting on the ends of steel cantilevers riveted to the ends of each cross-girder. The 250-ft. spans were built on staging mounted on four trolleys. They were then run forward to overhang, and a hulk was placed under the end at low water, and lifted the end of the span on the tide rising. Span and hulk were then hauled across the opening, till the end of the span projected over its position on the centre pier. On the tide falling, the span came down on to its bearings and the hulk was removed.

Drainage Works.—The Board of Trade has received a communication to the effect that a competition for plans for prospective drainage works at St. Petersburg will be opened in the Russian capital on Aug. 31st next. Awards to the value of 12,000, 8,000, and 5,000 roubles respectively will be granted to the three sets of plans which are judged to be the best. A copy of

the conditions (in Russian) of the above competition has been received at the Board of Trade through the courtesy of the Russian Financial Agency in London, and may be consulted, according to the *Board of Trade Journal*, at the Commercial Intelligence Branch of the Board of Trade, 50, Parliament Street, any day between the hours of 10 a.m. and 5 p.m.

Harbour Works at Touram.—In the *Journal Officiel* for the 6th of December last a decree of the Governor-General is published, sanctioning the creation of a harbour at the north of the town of Touram, to the west of the river of the same name. The work, which should be of interest to enterprising engineering firms, will comprise a breakwater about 2,950 mètres long; a stone quay 1,000 mètres long, with platform; the dredging of certain points of the harbour; warehouses and movable cranes; railway lines, with a branch line to the west of Touram, to connect with the railway terminus. The expense for these works is estimated at 9,500,000 frs. (£380,000), and the cost will be charged to the general Budget of Indo-China.

ELECTRICAL ENGINEERING.

Electrical Fans.—We quote the following from an interesting report on the efficiency of electrical fans constructed by Messrs. John Gibbs & Sons, signed by Dr. Hele-Shaw, F.R.S., Professor of Engineering, Liverpool University College, and Mr. Alfred Hay, B.Sc., M.I.E.E., Lecturer on Electro-Technics at the same institution. One of the two fans tested was a 24-in. fan, while the other, driven by a watertight completely enclosed motor, was a 15-in. fan:—"The 24-in. fan (No. 205)," says the report, "when supplied at a potential difference of 100 volts, was found to take a current of 3.05 amps. and to run at a speed of 655 revolutions per minute, delivering 5,100 cub. ft. of air per minute The temperature rise after 3½ hours' run was found to amount only to 23 degs. Fahr. The same fan, when fitted with a conical discharge-pipe, tapered from 24 ins. to 12 ins., was found to take 3·2 amps. at a potential difference of 105 volts, discharging 1,360 cub. ft. per minute. The pressure in the discharge-pipe was found to exceed that of the atmosphere by an amount corresponding to a column of water ¼ in. high. The smaller fan (No. 247) . . . when supplied at a potential difference of 110 volts, was found to run at a speed of 695 revolutions per minute, taking a current of 1 amp. and giving a discharge of 1,160 cub. ft. per minute. The temperature rise was found to be 50 degs. Fahr., which is well within the limits of safety. The running of the 15-in. fan was remarkably smooth and silent." The two scientists charged with the test add that they consider the above results as highly satisfactory, and that the mechanical construction of the fans is substantial and the workmanship good, which will undoubtedly be accepted by firms requiring ventilating fans as a valuable guarantee, and cannot but increase the already great demand for Messrs. Gibbs & Sons' manufactures.

RAILWAY AND ROAD TRACTION.

Railway Construction.—In a paper read on Jan. 26th this year at the meeting of the Institution of Junior Engineers Mr. Alexander Ross, M. Inst. C.E., Honorary Member of the Institution, described the general course followed in constructing a new railway line, from the preliminary survey and the estimate of probable cost to the completion of the line, concluding with general remarks on signalling. The paper gave a very lucid outline of the sequence of the various portions of the work, and may be read with great advantage by all engineering students.

MISCELLANEOUS.

Works Management.—There is no doubt that the spoken word makes generally a far deeper impression upon the human mind than the written word, which is easily recognised when we compare an education derived from attending lectures with that derived from reading only. For this reason, among many others, engineering students owe gratitude to those who have made the arrangements for a course of six lectures to be delivered on works management, under the auspices of the Institution of Junior Engineers, at the Westminster Palace Hotel. The first of these lectures, delivered by Mr. A. H. Barker, Wh.Sc., B.A., B.Sc., Mr. Percival Marshall being in the chair, was, as had been expected, attended by a very large audience, and those who were present are not likely to miss any of the subsequent lectures. The area covered by the lecturer was very wide, perhaps somewhat too wide for the time allowed for its discussion, though, of course, the subjects alluded to were outlined merely. Mr. Barker dealt with the general state of organisation in this country, with special application to engineering firms; the causes of our present industrial position; the selling power of products; the best methods of dividing orders so as to provide continuous work for operatives; the proportion of workers required in the different shops, etc. He illustrated his propositions by valuable curves showing the relative cost in each case of machine tools, fitting tools, etc., and entered also upon the problems of suitable buildings, of driving power—electrical as compared with mechanical, and concluded with calculations for the determination of particulars in connection with the size of steam engines and boilers. The lecture, as customary, was followed by an interesting discussion, after which the lecturer added such information as had been asked by those taking part in the debate. The eminently practical value of such lectures is obvious, and it may be anticipated that the remaining five lectures will attract an even larger audience than that present during the introductory lecture.

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In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

This systematic record should prove of the greatest value to those of our readers interested in one or more specific sections of technology, trade or economics, or to those who have insufficient leisure to peruse the large number of publications now appearing.

In most cases where publications are not readily procurable, with the exception of Transactions of the Learned Societies, copies of the articles can be supplied on application by remitting 7d. Should any of our readers desire further information we shall be happy to supply it.

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ARCHITECTURE AND BUILDING.

1. Construction and Design.

Domestic Architecture.—*The Planning of Small Country Houses.* A paper read by M. H. Baillie Scott before the Liverpool Architectural Society, in which the author fully discusses the main features which an architect should take into account in planning a small house such as most of us live in.—*Builders' Journal*, Jan. 23rd, 1901, pp. 468-472.

—— *Flats.* By Edwin T. Hall, F.R.I.B.A. A paper, read in January at a meeting of the Architectural Society, dealing with family dwellings until a comparatively recent period quite unknown in London, and still unknown in the provinces, though becoming more and more popular in the metropolis. The author's suggestions, therefore, regarding the most suitable arrangements of the various rooms, offices, stairs, etc., are of interest to a very large number of persons.—*Builders' Journal*, Jan. 23rd, 1901, pp. 479-481.

Paper Mill.—*The Great Northern Paper Company's New Mill.* Description of a very large paper mill, about 80 miles north of Bangor, Me., on the Bangor and Aroostook Railroad, at the town of Millbrocket, in which all the inhabitants, directly or indirectly, derive their living from this great industrial enterprise. — *Engineering Record*, Dec. 15th, 1900, pp. 560-66. (Ill.)

Stone Carving.—*The Minor Classic Enrichments.* By G. A. T. Middleton, A.R.I.B.A. The author points out that according to a very general law, that the less shall foreshadow the greater, it has frequently happened that minor carved enrichments have been more precocious in development than larger architectural monuments, which should induce the present-day carver to instil his enrichments with beauty, and buildings fit for them will follow. The motives should all be taken from nature.—*Stone Trades' Journal*, Jan. 1901, pp. 126-28. (Ill.)

Stable Roof. — *A Steel-Concrete Stable Roof.* Description of a roof placed on the two-storey fire-proof building of the Anglo-Swiss Condensed Milk Company, Brooklyn, which has a length of 200 ft. and a width of 88½ ft. The roof is a three-span roof, supported on steel columns and independent of the brick walls. The trusses have a span of 28 ft. 11 ins., and are made with pairs of light angles, with all connections completely shop-riveted. —*Engineering Record*, Dec. 22nd, 1900, pp. 595, 596. (Ill.)

2. Heating and Ventilation.

Heating and Ventilation.—*Heating Coils and other Apparatus.* By William S. Monroe. The author, continuing his contribution on the "Modern Practice in Steam Heating," remarks that in ordinary latitudes it is necessary to provide heating coils for all fans which take air from the outside and blow it into buildings for ventilating purposes, which he describes, together with other necessary accessories.—*Engineering Record*, Dec. 29th, 1900, pp. 621-24. (Ill.)

Heating and Ventilation.—*Notes on Heating and Ventilation.* Digest of paper on the heating and ventilation of greenhouses; on the heating and lighting power of coal gas; on heating and cooking by gas; on the amount of gas to heat a room 14 ft. by 14 ft. by 10 ft.; on ventilation by aspiration, by means of a convergent-divergent apparatus, described by M. Paul Petit at Paris, etc.—*Engineering Record*, Jan 12th, 1901, p. 41.

Ventilation.—*Ventilating and Heating the Palace of the Crown Prince of Japan.* The palace referred to was erected from designs prepared in the United States, at a cost of 3,000,000 dols., and the ventilating and heating plant with which the building is to be equipped comprises a hot-blast steam apparatus for warming the main apartments and state rooms, direct radiation for the basement and corridors, and a refrigerating system for reducing the disagreeably high degree of humidity of the air during summer months.—*Engineering Record*, Jan. 19th, 1901, pp. 62-65. (Ill.)

3. Plumbing and Gasfitting.

Plumbing.—*The Effect of Heat and Cold on Plumber Work.* By Thomas Hume. F.I.S.E. The author points out that although we are familiar with the effects of temperature on metals, the effects on plumber work is not so obvious. Until quite recently, in fact, they were considered as of no importance; but since the introduction of hot-water systems, high-pressure boilers, circulating tanks, etc., the effects of heat and cold on plumber work must be taken into consideration. The author, therefore, gives an interesting analysis on the changes occurring in lead-work on roofs, zinc roofing, sheet copper, internal plumber work, etc., and deals with expansion boxes, jointing of hot-water pipes, the choking of pipes, drain, soil, and ventilating pipes, cast iron, and the freezing of water in pipes.—*Builders' Journal*, Jan. 2nd, 1901, pp. 418-22.

—— *Plumbing Details in the Residence of Dr. E. H. Dunham.* Description of the plumbing details in a New York residence, which has four storeys, besides basement cellar, and which is equipped with an extensive plumbing system, including the water supply and drainage for five bath-tubs, ten wash-basins, four slop-sinks, and the usual fixtures in butler's pantry, kitchens, scullery, and laundry.—*Engineering Record*, Dec. 22nd, 1900, pp. 600-2. (Ill.)

4. Miscellaneous.

Architectural Relics.—*Ancient London.* By J. Hutchings, A.R.I.B.A. The author repudiates the statement that the City of London lacks picturesqueness, and describes various interesting relics.—*Builders' Journal*, Dec. 12th, 1900, pp. 364, 365, and Dec. 19th, 1900, pp. 382, 383. (Ill.)

Architectural Tendencies.—*Some Tendencies of the Modern School of Architecture.* Abstract from a paper read by Professor Beresford Pite before the Royal Institute of British Architects, in which the author suggests that modern architects should do more than follow ancient traditions, and solve problems in their own ways.—*Builder*, Dec. 22nd, pp. 563-65.

Building Materials.—*The Effect of Freezing on Concrete.* By Walter A. Rogers. Abstract from a paper read before the Western Society of Engineers, U.S.A., in which the author describes the results of experiments made in order to determine as far as possible the changes caused by freezing Atlas Portland cement concrete and Louisville cement concrete, which are taken as types of Portland and natural cements.—*Builders' Journal*, Jan. 2nd, p. 423.

Celtic Monuments.—*Thoughts upon Ancient Monuments, Celtic Ones in Particular.* By Harry Hems, of Exeter. The article mainly deals with graveyard ornaments in the form of Celtic crosses.—*Stone Trades' Journal*, Dec. 1900, pp. 107-9. (Ill.)

Colour.—*Colour in Architecture: Seen Through an Artist's Glasses.* By Mr. A. Wallace Rimington. A paper read before the Architectural Association, in which the author, after deploring the gradual decay of artistic colouring, points out its great importance by referring to pictures as well as buildings which are distinguished by their pleasing coloration, and pleads for the consideration of colour-effect in the design of architectural work. The paper is extremely interesting, above all by the careful analysis of pleasing colour harmonies and reference to musical harmony.—*Builder*, Dec. 15th, 1900, pp. 534-39.

Decoration.—*Tiles used in Business Premises.* By Silvester S. Wherby, M.S.A. The author describes the use of tiles for walls and ceilings, and also for the exterior coating of columns in large halls where they are required owing to the extensive span.—*Stone Trades' Journal*, Dec. 1900, pp. 103-6. (Ill.)

Mediæval Monuments.—*Monreale the Magnificent.* By William Durban, B.A. The author points out that of all parts of Italy none is so rich in monuments of architectural beauty as Sicily, where all of the great conquering races, Phœnicians, Greeks, Romans, Normans, Spaniards, and Italians are represented, and that of all edifices to be found there the great Norman Cathedral of Monreale is the gem. He then describes the architectural features of this unrivalled specimen of Norman architecture, which, notwithstanding its venerable antiquity, is wonderfully fresh and intact.—*The Stone Trades' Journal*, Jan. 1901, pp. 134-36. (Ill.)

Medieval Towns.—*Bury St. Edmunds.* By Edward Walker. Interesting description of the architectural relics of the town above-named, which, though not so rich in domestic specimens as Ipswich, has some splendid specimens, notably the remnants of the famous ancient abbey and the churches of St. Mary and St. James.—*Builders' Journal*, Jan. 23rd, p. 468. (Ill.)

—— *Two German Towns.* Description of the towns of Worms and Frankfort-on-Maine, both of which are rich in architectural relics, among them the Cathedral at Worms, and, at Frankfort, Luther's House, of which drawings accompany the article.—*Builders' Journal*, Dec. 19th, 1900, pp. 384, 385. (Ill.)

—— *Ipswich.* By Edward Walker. Description of a number of very interesting architectural relics of medieval times, most of them of a domestic character, the material prevailing being flint and freestone or rubble.—*Builders' Journal*, Jan. 2nd, 1901, pp. 416, 417. (Ill.)

CIVIL ENGINEERING.

1. Bridges.

Bridges.—*Raising the Boston Bridge, near McKeesport.* In order to raise the bridge to the level of an elevated crossing, constructed after the bridge was finished, it was determined to raise one end of it and build from it a new 150-ft. approach to grade on the higher part of the river bank, beyond the railroad tracks. The method by which this was done, and the manner in which the engineering difficulties were overcome, is described in this article.—*Engineering Record*, Dec. 15th, 1900, pp. 569, 570. (Ill.)

Bridges.—*Plate Girder Footbridge, at Madison, N.J.* Description of a very attractive little structure, consisting of two parallel arched plate girders, carried by masonry abutments, which also form the stairway approaches. The girders have a span of 50 ft., and are placed 10 ft. apart centre to centre.—*Engineer*, Nov. 30th, 1900, p. 539. (Ill.)

—— *Swing-bridges over the Weaver.* Description of the new swing-bridges on the river at Norwich across the little River Weaver, on which are to be found some of the most interesting examples of inland navigation engineering that the country has produced, the most notable being the celebrated hydraulic lift at Anderton.—*Engineering*, Dec. 14th, 1900, pp. 757-60. (Ill.)

—— *Reinforcing and Rebuilding the Cornwall Bridge Piers.* At Cornwall Island, just below the Long Sault Rapids, the Ottawa and New York Railway crosses the St. Lawrence River on a steel truss-bridge, with three 370-ft. spans over the south channel, and a cantilever span 840 ft. long between anchorages over the north channel. While the superstructure was being erected one of the south channel piers collapsed, and was rebuilt in December, 1899. The cantilever bridge over the north channel has a 420-ft. centre span and two 210-ft. anchor arms, two main piers in the river, and two anchor piers on the banks. The north anchor pier was removed and rebuilt, and the adjacent main pier in 26 ft. of water was reinforced by enclosing it with a steel and concrete jacket. These operations are described in the article.—*Engineering Record*, Dec. 29th, pp. 613-15. (Ill.)

Viaducts.—*The New Kinzua Viaduct.* This is an interesting contribution, giving full structural details of a new viaduct to replace an older one on the Erie Railway, completed in September last. The total weight of the new structure is 6,700,000 lbs., and it was erected by an average force of about 100 men in four months, notwithstanding repeated delays from strikes, etc.—*Engineering Record*, Dec. 1st, 1900, pp. 508-12. (Ill.)

—— *The Gokteik Viaduct, Burmah. I.* Description of a noteworthy viaduct in Burmah, built by the Pennsylvania Steel Company, under the direction of Mr. J. V. W. Reynders, superintendent of the bridge construction department, for the Burmah Railway Company, Ltd.—*Engineering Record*, Jan. 12th, 1901, pp. 26-28. (Ill.)

2. Canals, Rivers, and Harbours.

Harbours and Rivers.—*Harbours and Waterways in the Nineteenth Century.* The article recalls the conditions of our harbours and waterways in the beginning of the century, and dwells on the great progress effected in the development of the mercantile marine of this country during the last hundred years.—*Engineer*, Jan. 1st, 1901, pp. 1-2.

Locks.—*The Concrete Lock near St. Paul.* Abstract of a portion of the annual reports for 1899 and 1900, submitted by Major F. V. Abbot to General John M. Wilson, chief of engineers, referring to a timber dam and a concrete lock at two points between St. Paul and Minneapolis, constructed in connection with the Mississippi Improvement Works.—*Engineering Record*, Dec. 22nd, 1900, pp. 593-94.

—— *Devizes Lock, Kennet and Avon Canal.* Description of the remarkable old waterway above-named, on which the flight of 15 locks near Devizes was in its day considered a masterpiece of skilful engineering. In fact there are no fewer than 29 locks within 2½ miles from Devizes. This waterway is kept in excellent order by the Great Western Railway Company, its present owners.—*Engineer*, Nov. 30th, 1900, p. 550 (Ill.)

ELECTRICAL ENGINEERING.

1. Electro-Chemistry.

Electro-Chemistry. — *Some Recent Progress in Electro-Chemistry.* The author of this contribution indicates in a general way the lines upon which progress has been made during the last year, and, after pointing out how very small is the share that England has had in this progress, while France owns 93 of the total of 161 electro-chemical works in existence, deals with the metallurgy of aluminium, zinc, copper, gold, and with chlorates and hypochlorites. (To be continued.)—*The Electro-Chemist and Metallurgist*, Jan. 1901, pp. 1-4.

—— *Electro-Chemistry at the Paris Exhibition.* The article begins with a short reference to the calcium carbide production, and after this the author reviews the exhibits referring to electro-deposition, gold recovery, special features of calcium carbide manufacture (supplementing the introductory remarks), aluminium manufacture, electrolytic manufacture of alkali and bleach, furnaces, etc. (To be continued.)—*Electro-Chemist and Metallurgist*, Jan. 1901, pp. 6-12.

—— *On Some of the less well-known Carbides, Borides, and Silicides.* By R. S. Hutton. The author, after paying tribute to Professor Moissan, deals shortly with the carbides of the alkalies and alkaline earth, the carbides of aluminium and beryllium, and with manganese carbide, the carbides of the rare earths, cerium, etc., after which he refers to the silicides and borides, etc.—*Electro-Chemist and Metallurgist*, Jan. 1901, pp. 4-6.

2. Electric Lighting.

Electric Light.—*The Nernst Lamp.* Description of improvements recently made in the Nernst Lamp, for which the "Nernst Electric Light" Co., Ltd., has acquired the patents for the Colonies (excluding Canada) and various remote countries. It appears that the shareholders of the company invested £270,000 out of a total capital of £320,000 for the patent rights, which seems a rather heavy percentage, but, owing to Mr. Swinburne and the technical staff of the company, the Nernst Lamp is at present apparently a thoroughly practical and useful apparatus.—*Electrician*, Dec. 7th, 1901, pp. 230-32. (Ill.)

—— *Observations on Crookes' Tubes.* By H. Westbury. Abstract of a paper read before the Röntgen Society of the United States at New York City, on Dec. 14th, 1900, in which the author discusses the most important phenomena observable in Crookes' tubes.—*Western Electrician*, Jan. 5th, 1901, p. 21.

Electric Lighting. — *Modern Electric Lighting Plant.* By R. D. Summerfield. A contribution in which the author gives a concise description of electric lighting machinery generally as used at the present day, including boilers, engines, generators, and all auxiliary apparatus connected therewith.—*Electrical Engineer*, Jan. 18th, 1901, pp. 88-89, and Jan. 25th, 1901, pp. 115-17.

—— *The Electric Light.* By Richard H. Pierce. Concise review of the gradual evolution of electric lighting from the time of the invention of the voltaic battery in the last year of the eighteenth century to the end of the nineteenth century.—*Western Electrician*, Jan. 5th, 1901, pp. 5-6. (Ill.)

Electric Lighting Generators.—*Some of the Requisites of Modern Lighting Generator Sets.* By N. G. Reist. Abstract of a paper dealing with the above subject, read at the meeting of the Engine Builders' Association, U.S.A.—*Electrical Engineer*, Jan. 18th, 1901, pp. 81, 82.

—— *Generating Set of 5,000 h.p. for Brooklyn.* Description of an electrical generating set, built for the King's County Electric Light and Power Company, at Brooklyn, being one of two such sets turned out at the Westinghouse Works, near Pittsburg.—*Western Electrician*, Jan. 5th, 1901, p. 23. (Ill.)

Electric Lighting Plants.—*Efficiencies of Small Electric Lighting Plants.* A paper by A. W. Richter and B. V. Swenson, in which the authors present some of the principal results, data and conclusions derived from tests made upon four lighting plants, situated in cities, the populations of which range from 2,500 to 18,000 inhabitants, and may be considered fair types of electric lighting plants, such as are found in the smaller cities of the United States.—*Journal of the Western Society of Engineers, U.S.A.*, pp. 470-87. (Ill.)

Lighting a Hospital.—*The Electric Lighting of the Liverpool Royal Infirmary.* By E. T. Bradburne, A.M.I.C.E. Description of an electric lighting plant for the above-named infirmary, which, ever since it was built 13 years ago had been lighted by gas standards placed down the centre of the room, a very inadequate illumination for many purposes. The electric plant, consisting of 254 lights, is the generous gift of Mr. G. H Melly, of Liverpool, and was designed and carried out by Messrs. H. T. Boothroyd, Hyslop & Co., of Bootle, who made many improvements in the usual method of hospita lighting.—*Electrical Engineer*, Jan. 18th, pp. 79-81 (Ill.)

Power and Lighting Plant.—*Electrical Industries in Bangkok, Siam.* Description of a number of electrical undertakings, including tramways, lighting and power plants, erected within the last 10 years in Bangkok, Siam.—*Electrical Review* (New York), Jan. 5th, 1901, pp. 16, 17.

3. Power.

Electricity for driving Pumps.—*Electrical Pumping of Sewage.* Concise descriptions of an up-to-date sewage plant at the tiny village of Combs, Suffolk, consisting of two sets of machinery, comprising each a three-throw pump driven by an electric motor through worm gearing.—*Electrical Engineer*, Dec. 14th, p. 845. (Ill.

Electric Plant.—*Electrical Equipment of the South Eastern and Chatham Railway Co.'s Locomotive Sheds at Slade's Green.* Description of the interesting plant for a shed affording accommodation for 120 locomotives, which offers results so satisfactory, both as regards convenience and economy, that it should induce the owners of other works to adopt electrical distribution in place of all other methods.—*Electrician*, Dec. 21st, pp. 305-9. (Ill.)

Power Distribution.—*The Case for Electric Power Distribution.* By W. B. Esson, M.I.C.E., M.I.E.E. Abstract of a paper read before the Civil and Mechanical Engineers' Society, in which the author points out that he is not referring to electrical transmission — the superiority of which for all distances beyond a mile is taken for granted—but to distribution in factories and workshops, and desires to find out whether electrical distribution has advantages over the two other kinds usually met with, *i.e.* distribution by using a number of smaller engines instead of one large one, and distribution by shafting, belts, or ropes.—*Electrician*, Jan. 18th, 1901, pp. 461-64, and Jan. 25th, 1901, pp. 503-6.

—— *Relative Advantages of Direct-Current and Three-Phase Distribution for Small Installations.* By H. A. Earle, M.I.C.E., M.I.E.E. Abstract of a paper read before the Manchester section of the Institution of Electrical Engineers, in which the author compares the relative advantages of the two systems, and comes to the conclusion that in cases where lighting alone is required the first cost of both systems appears to be equal, but the simplicity of the direct-current system renders its adoption preferable. When a number of motors are on the circuit, for whatever purpose, and regardless whether lighting is included or not, the direct-current system has decided advantages except in a few special cases; moreover, the use of batteries is all but excluded with polyphase systems, and this is an important consideration. — *Electrician*, Dec. 28th, 1900, pp. 359-62.

Power Plant.—*The Plant of the St. Croix Power Company, of Wisconsin.* By Henry Floy. Abstract of a paper presented at the 148th meeting of the American Institute of Electrical Engineers, in which the author describes the completion and starting of a 25,000-volt plant, which contains many novelties and features of interest, both hydraulic and electrical.—*Electrical Review* (New York), Dec. 5th, 1900, pp. 604-607; Dec. 12th, pp. 635-37; and Dec. 19th, pp. 660-64. (Ill.)

—— *Power Transmission Plant at Renturia, Spain.* By Frank C. Perkins. Description of a continuous-

current high-tension power transmission plant erected to supersede a steam plant at the paper works of the Société Vasco Belga, at Renturia, near San Sebastian, Spain.—*Electrical Review* (New York), Jan. 5th, 1901, pp. 15, 16. (Ill.)

Power Transmission.—*Practical Notes on Water-Power for Electrical Purposes.* By F. R. York. Abstract of a paper read before the Glasgow section of the Institution of Electrical Engineers, in which the author discusses some of the principal types of plant used in this country, and indicates the particular uses for which they are most used.—*Electrician*, Jan. 11th, 1901, pp. 736-38.

Power Supply.—*Electricity Supply Works in 1898 and 1899.* The author describes, on the basis of tables and curves that accompany his article, the actual and average expenditure for electricity supply during the two years above-mentioned.—*Electrician*, Jan. 4th, 1901, pp. 382-88.

4. Telegraphy and Telephony.

Submarine Telegraphy.—*Sine-Wave Submarine Cable Telegraphy.* Description of a very interesting method of sending cable messages, devised by Dr. Albert C. Crehore and Dr. George O. Squier, captain in the United States Signal Corps, well known through their remarkable polarising photo-chronograph. This method, which has been tested on two lines of the Commercial Cable Company and the utility and value of which has now been established beyond a doubt, consists in telegraphing by sine-waves, and the time seems to be near when cable messages will be sent by means of alternating current dynamos instead of by batteries.—*Engineering*, Jan 4th. 1901, pp. 1-6. (Ill.)

5. Miscellaneous.

Electric Arc.—*The Direct-Current Arc.* By W. Duddell, Wh.Sc. Associate. Abstract of a paper read before the Institution of Electrical Engineers, in which the author explains that he uses the term "direct current" in the sense of a current supplied by cells, or by a direct dynamo, and does not wish to indicate that it is necessarily constant in value. The effect of varying the current through the direct current very slowly has been completely investigated by Mrs. Ayrton, and to her also is due the honour of having carefully investigated the effect of very sudden changes, a gap being left in the experimental evidence as to what occurs between very slow variations and isolated sudden changes in the current. The author's experiments were intended to fill this gap. (To be continued.)—*Engineering*, Dec. 21st, 1900, pp. 799-800.

Electrical Engineering.—*Electrical Engineering at the Paris Exhibition.—No. VIII.* The article deals with the exhibits of the Société Gramme, one of the very oldest pioneers in the field of electrical engineering, but still showing as much vitality as ever. Its second portion is devoted to the Parsons' exhibit in the English section, mainly two steam turbo-dynamos, each of them being of a distinct type of combined plant.—*Engineer*, Dec. 21st, 1900, pp. 608, 609. (Ill.)

MARINE ENGINEERING AND SHIPBUILDING.

1. Merchant Vessels.

Atlantic Liners.—*New Furness Liners.* Description of the handsome passenger steamer *Evangeline*, sister ship to the *Loyalist*, built by Messrs. Alex. Stephen & Sons, Linthouse, Govan, to the order of Sir Christopher Furness, these vessels being intended to run on the Furness Line with passengers and cargo between London, Halifax, and St. John, N.B.—*Marine Engineer*, Jan. 1st, 1901, pp. 402-407. (Ill.)

Pacific Liners.—*Ocean Steamships Building for J. J. Hill at New London, Conn.* Description of mammoth Pacific liners, building for the Great Northern Steamship Company, by the Eastern Shipbuilding Company, of New London, Conn., U.S.A., which will surpass in tonnage, displacement, and carrying capacity the most colossal of the European liners built or building. The keels of these gigantic vessels are already laid. They are designed primarily for cargo carriers, and are not so long as some of the biggest European ships, but are much wider and deeper. Their dimensions are: Length, 630 ft.; beam, 73 ft. 6 in.; depth, 55 ft. 8 ins. They will be of about 21,000 gross tons register and 33,000 tons displacement, or just 10,000 tons more displacement than the new Atlantic liner *Deutschland.*—*Marine Engineering*, Dec. 1900, pp. 534, 535. (Ill.)

2. Pleasure Craft.

3. Equipment and Machinery.

Auxiliary Machinery.—"*Invincible*" *Centrifugal Circulating Pumping Engines.* Description of a new design of pumping engines of the high-pressure single-acting type, as manufactured by Messrs. J. & H. Gwynne, Ltd., 81, Cannon Street, London, E.C.—*Steamship*, Jan. 1901, p. 268. (Ill.)

Marine Engines.—*Engines of the "Inchdune" and "Inchmark."* Description of the engines on the two above-named ships of the "Inch" line of steamers, owned by Messrs. Hamilton, Fraser & Co., of Liverpool, who deserve credit for having been the pioneers in the renewal of the practice of superheating on board ship.—*Engineering*, Jan. 4th, 1901, p. 9. (Ill.)

4. Docks.

Docks.—*Dock Extensions in the Bristol Channel.* Description of a number of projects for new docks and dock-extensions, extending from Bristol westward as far as Swansea, or even Llanelly, to be presented next Session before the Private Bill Committee of the House of Commons.—*Engineer*, Dec. 14th, 1900, pp. 586-87.

5. Miscellaneous.

Dredgers.—*The Bates Hydraulic Dredger.* Description of a new hydraulic dredger, constructed at the Walker Shipyard of Sir W. G. Armstrong, Whitworth & Co., Ltd., to the order and from the designs of Mr. Lindon W. Bates, and forming part of a contract for four dredgers, aggregating about 11,100 h.p., which Mr. Bates placed with the above firm in 1899. The dredging and propelling machinery was constructed by the Wallsend Shipway and Engineering Co., Ltd. The general design and appearance of the dredging vessel has been much influenced by its having to perform the journey to Queensland under its own steam.—*Engineering*, Jan. 11th, 1901, pp. 43-45. (Ill.)

Shipbuilding.—*Shipbuilding and Marine Engineering.* Summary of the work above described during the last year of the century, which marked the highest attainment in the volume as well as in the character of the merchant vessels built, even the record total of the private yards of the country for 1899 being exceeded, although, for special reasons, the tonnage of naval ships actually floated was less than in preceding years. (To be continued.)—*Engineering*, Jan. 4th, 1901, pp. 10-14, and Jan. 11th, 1901, pp. 39-43.

—— *Twin-Screw Combined Fire Tug and Police Boat.* Description of a powerful vessel of the above description, designed and built by Messrs. Merryweather & Sons, of London, to the order of the Mexican Government for the port of Vera Cruz; this vessel, which is seaworthy, is built of best Lloyd's tested Siemens-Martin steel.—*Engineering*, Jan. 11th, 1901, pp. 45, 46. (Ill.)

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Boilers.—*Compound Direct-Acting Boiler and Feed Pump.* Description of a pump designed by Mr. J. P. Hall, the head of the firm of Messrs. J. P. Hall & Sons, Ltd., of Peterborough, in order to remedy the low efficiency from a thermo-dynamic standpoint of the ordinary feed-pump.—*Marine Engineer*, Feb. 1st, 1901, pp. 467-69. (Ill.)

Boiler Tubes.—*The Plastic-Pressure Tube Expander.* Description of a method which is intended to supersede the expansion of boiler tubes by means of a taper mandril and rollers which has been in use for many years; the

new method being one by which tubes are expanded by plastic pressure, an invention of Dr. C. V. Burton, of the Newall Engineering Company, Ltd., 141, Queen Victoria Street, London, E.C.—*Engineering*, Dec. 21st, 1900, p. 798. (Ill.)

Fuel.—*Bituminous Coal as a Cupola Fuel.* The author expresses the opinion, based on experiments, that in several parts of the United States where bituminous coal is mined it could advantageously be employed as a cupola fuel by small jobbing foundries where other fuel is expensive.—*Foundry*, Jan. 1901, pp. 194-5.

—— *Burning Powdered Coal in Stationary Boilers.* Description of an apparatus for burning powdered coal in a stationary boiler, consisting of a hopper in which the pulverised coal is put, a revolving cylinder in the bottom of the hopper which extends across the boiler front, and of a gate in front of the furnace with a row of teeth at the bottom edge and with mechanism for raising and lowering.—*Engineering Record*, pp. 615, 616. (Ill.)

2. Compressed Air.

3. Engines and Motors.

Engine Cylinders.—*Corliss Cylinders.* Description of a type of cylinder in which all working parts, valves, steam and exhaust openings, etc., are on one side of the casting only. These cylinders are made in various sizes, from 12 ins. to 100 ins in bore, and weigh from 2,000 lbs. to 33,000 lbs. The sizes most in demand, however, are those varying from 18 ins. to 56 ins. — *The Foundry*, Jan. 1901, pp. 196-99. (Ill.)

Engines.—*The Koerting Two-Cycle 350 Brake Horse-Power Gas Engine.* Description of an engine, resembling a steam engine, which deserves careful study. In this engine the single working cylinder is double-acting, and has one piston-rod, one crosshead working through guides, and one crank. The article contains a detailed description of the various features, taken from a paper by Professor Meyer, read before the Verein von Gas-und-Wasserbau Männern.—*Engineer*, Jan. 4th, 1901, pp. 23-4. (Ill.)

—— *Prime Movers at the Paris Exhibition.* The article describes a horizontal compound steam-engine, built by the Erste Brünner Maschinenfabrik Gesellschaft at Brünn, Moravia, being connected with a 2,200 volts dynamo, built by Gauz & Co., Pesth, and generating 1,200 kilo-watts. The engine is designed for slightly superheated steam of 12 atmospheres pressure and 125 revolutions per minute, and is provided with an injection condenser. With tenfold expansion it develops about 1,000 brake horse-power, and about 800 with fourteenfold expansion. Under these conditions and a good vacuum, the consumption is stated to be 5·2 kilos = 11½ lbs. per horse-power hour.—*Engineer*, Nov. 30th, 1900, pp. 556, 537. (Ill.)

—— *Prime Movers at the Paris Exhibition. No. XV. Swiss Section—Escher, Wyss & Co.* Description of engines of the firm above named, notably a 1,000 h.p. horizontal compound engine, with the cylinders placed tandem.—*Engineer*, Dec. 14th, 1900, pp. 583-86. (Ill.)

Steam Turbines.—*Turbine Propulsion for Clyde River Steamers.* The author of the article points out that as the beginning of last century saw the momentous advent of steamship propulsion on the Clyde, so the beginning of the present will see an event of almost as great importance, if not as that of the appearance of the "Comet," at least as that of the compound or triple-expansion engine, namely, the inauguration of steamers propelled by turbines of the Parson's type.—*Marine Engineer*, Feb. 1st, 1901, pp. 469-70.

4. Power and Transmission.

Elevators.—*The "Escalator," or Continuous Elevator.* Description of the continuous moving staircase, shown by the Otis Elevator Company of New York, which served for establishing connection between ground and first floors in the United States Textile Section at the Paris Exhibition. The device described is not a travelling band, such as was employed in various places to carry passengers to higher levels, but it has treads and risers, and when at rest can be ascended and descended just as any other staircase. *Engineering*, Nov. 30th, 1900, pp. 699. (Ill.)

Cranes.—*Brakes for Electric Cranes.* The article contains a concise description of various types of electrically operated brakes suitable for electric cranes, and the author points out the conditions suitable for this or the other form.—*Engineer*, Nov. 30th, 1900, p. 538.

—— *Cranes at the Paris Exhibition.* The author points out that steam cranes were nearly non-existent, hand cranes were but slightly represented, while electrical cranes predominated overwhelmingly, and then deals generally and critically, not descriptively, with the characteristic exhibits.—*Engineering*, Nov. 30th, 1900, pp. 689, 690. (Ill.)

5. Machine Works, Shops, and Foundry.

Core Oven.—*The Taggart Core Oven.* Description of a core oven designed by F. S. Taggart, the superintendent of the Missouri Malleable Iron Company, at East St. Louis, Ill., possessing various features of interest, the object having been to produce an oven which shall be at all times ready of access and which can be kept at the same time in continuous operation.— *The Foundry*, Jan. 1901, pp. 189, 190. (Ill.)

Foundry.—*Cast, Forged, and Flanged Work at Paris.* Comments on exhibits coming under the above heading, which, of course, were of great interest to practical men wishing to compare foreign work with their own, but were rather scattered among the different sections.—*Engineering*, Dec. 7th, 1900, pp. 721, 722. (Ill.)

Moulding.—*Machine Moulding.* Abstract from a paper, by L. L. McCord, read at the meeting of the Foundrymen's Association, U.S.A., in which the author discusses the various types of moulding machines with reference to their adaptation for the individual requirements of various foundries, their economy, and their fitness for rendering the manufacturer as independent as possible with respect to labour.—*The Foundry*, Jan. 1901, pp. 201-7.

Turbines.—1,000 *Kilo-watt Steam Turbine and Alternator.* Description of a generating unit of the above description, built by Messrs. C. A. Parsons & Co., of Newcastle-upon-Tyne, for the Electrical Supply Works of the City of Elberfeld, which, being tested by a committee of well-known experts, gave excellent results.—*Engineering*, Dec. 28th, 1900, pp. 830-31. (Ill.)

—— *Moulding a Propeller-Wheel in Green Sand.* The author describes a method of moulding a propeller wheel with four blades from a pattern of one blade in green sand.—*Foundry*, Jan. 1901, pp. 210-13.

6. Tools.

Machine Tools.—*Boyer Long-Stroke Pneumatic Hammer.* Description of a new type of pneumatic hammer introduced upon the market by the New Taite Howard Pneumatic Tool Company, Ltd., 63, Queen Victoria Street, London, E.C., which contains several interesting features from a mechanical point of view.—*Engineering*, Dec. 14th, 1900, pp. 767, 768. (Ill.)

—— *Machine Tools at the National Show.* The article gives an interesting description of the fine exhibits of Messrs. Alfred Herbert, Ltd., of Coventry, and of the work performed by their various machine tools, this working being a feature of the show.—*Engineering*, Dec. 7th, 1900, pp. 733-36. (Ill.)

—— *Machine Tools at the Stanley Show.* The article deals explicitly with a four-spindle semi-automatic lathe, built by Messrs. C. W. Burton, Griffith & Co., of Ludgate Square, E.C., and then describes, among others, Brockie's automatic triple-action chucking lathe, by the same makers; a Roberts' emery disc-grinder; a "Whiton" gear-cutting machine; a jig shown by the Aspley Engineering Company, Ltd.—*Engineering*, Nov. 30th, 1900, pp. 696-99. (Ill.)

—— *Milling Machine Heads at Paris.* The article referring to the very comprehensive exhibits of milling machines at Paris, makes special note of certain features of design which have for their object the adaptation of the milling spindle to work at various angles.—*Engineering*, Dec. 21st, 1900, pp. 787, 788. (Ill.)

MINING AND METALLURGY.

1. Coal and Coke.

Electricity in Coal Mining.—*The Most Recent Progress in the Application of Electricity to Coal Mining Operations.* The article deals in a very interesting manner with all the essential features of the subject, being mainly founded on the very extensive enterprise of Messrs. Siemens Bros. & Co., London, and Messrs. Siemens & Halske, of Berlin, and giving a comprehensive view of the most recent improvements made in mining plants by these well-known engineers.—*Iron and Coal Trades' Review*, Dec. 21st, 1900, pp. i.-xx., Supplement. (Ill.)

Coal Deposits.—*The Coalfields of the Philippines.* Description of a number of coalfields recently located and successfully worked by Americans. The best coal deposits so far found appear to be those discovered in the island of Bataan, where they occupy an extensive area.—*Iron and Coal Trades' Review*, Dec. 21st, 1900, pp. 1270-72.

Coal-Mining.—*American Anthracite Coal, Transport and Handling.* Description of the main features of the anthracite mining industry, which is one of the most important branches of the coal trade in the United States, the total output of this description of fuel now exceeding 50 million tons a year. The industry is almost entirely carried on in the State of Pennsylvania, and the fuel is used chiefly for domestic purposes in New York, Philadelphia, Boston, and other leading cities of the Eastern States.—*Iron and Coal Trades' Review*, Dec. 21st, 1900, p. 1272. (Ill.)

—— *Coal-Mining on Vancouver Island.* By R. Lind Watson. Description of the coal deposits and mines on Vancouver Island, which have been famous for years as the best on the Pacific coast. The author gives a short history of the mines and an account of the most important collieries, together with the method of development and mining.—*Mines and Minerals*, Jan. 1901, pp. 249.

—— *Alabama Mining Methods.* By J. E. Strong. The author describes the common methods used in working the Alabama coals. The seams now working vary from 2 ft. to 6 ft. in thickness, and they pitch from 2 degs. to 40 degs.—*Mines and Minerals*, Dec. 1900, p. 198.

Haulage.—*Endless Rope Haulage.* Description of a new endless rope haulage installed at the new slope, No. 3, Pratt Coal Mine, of the Tennessee Coal, Iron, and Railroad Co. at Ensley, Alabama.—*Mines and Minerals*, Dec. 1900, pp. 220, 221. (Ill.)

2. Copper.

Copper.—*The New York Copper Market during* 1900. Analysis of the copper market during the year, which, taking into consideration the unfavourable political situation in the United States and Europe, *i.e.* Presidential election and Boer war, remained remarkably steady, while at no time prices soared as high as in August, 1899.—*Engineering and Mining Journal*, Jan. 5th, 1901, pp. 9, 10.

3. Gold and Silver.

Gold Deposits.—*Farncomb Hill Gold Deposits.* By Prof. Arthur Lakes. The author describes the rich and peculiar gold deposits of Farncomb Hill, near Breckenridge, Colorado, and the methods of working them.—*Mines and Minerals*, Dec. 1900, p. 222.

Gold Dredging.—*Dredging for Gold.* By W. S. Russell, Chief Engineer, Vulcan Iron Works Co., Toledo, Ohio. The author points out that dredging for gold is a new opening for profitable investment of capital, and under proper management is a safe business proposition; he then quotes a number of interesting facts in regard to the operation of dredgers on placers at various places in the western portion of the United States.—*Mines and Minerals*, Dec. 1900, pp. 196, 197. (Ill.)

Gold Mining.—*Hydraulic Work in the Atlin Country.* Description of hydraulic work in progress on the Jaune Delamare hydraulic concession on Boulder Creek in the Atlin district in British Columbia.—*Engineering and Mining Journal*, Jan. 5th, 1901, p. 6.

Gold and Silver.—*Gold and Silver in* 1900. The article contains what appears to be a very close estimate of the gold production of the world in 1900, based upon the official reports, with estimates for the closing months, and special cable despatches.—*Engineering and Mining Journal*, Jan. 5th, 1901, pp. 10, 11.

4. Iron and Steel.

Iron Mines.—*Lake Superior Iron Mines in* 1900. By Dwight E. Woodbridge. The article summarises the output for the year and the ore shipments, the latter showing an increase of about 100,000 tons over 1899; not, however, what was expected early in the year, when mining activity was phenomenal. The shipment amounted to about 250,000 gross tons, and would have been several thousand tons larger had not cold weather come suddenly.—*Engineering and Mining Journal*, Jan. 5th, 1901, pp. 17-19.

Puddling.—*The Chemical Phenomena of Puddling.* By Lieut.-Col. Cubillo, A.I.C.E. Abstract of a paper read before the South Staffordshire Iron and Steel Institute.—*Iron and Coal Trades Review*, Nov. 30th, pp. 1110-12.

Steel and Iron.—*Influence of Copper in Retarding Corrosion of Soft Steel and Wrought Iron.* By F. H. Williams. This is a note read before the Engineers' Society of Western Pennsylvania, from which it appears that a small percentage of copper in steel is not prejudicial to its physical qualities or mechanical production, and that by adding a certain quantity of it soft Bessemer steel might be made as capable of resisting corrosion as wrought-iron.—*Engineering and Mining Journal*, Dec. 8th, 1900, p. 667.

5. Mining and Mining Methods.

Faults.—*The Great London Fault.* By Professor Arthur Lakes. The author describes the various phases of development of a great fault in the Mosquito Range, South Park, Colorado, in a noted gold and silver mine of that region, known as the London Mine Fault, because it passes in close proximity to the London Mine on London Hill, between North and South Mosquito Ranges.—*Mines and Minerals*, Dec. 1900, pp. 204, 205. (Ill.)

Mines.—*The American Nettie.* The article deals with the ore deposits near Ouray, in the San Juan Mountains, Colorado, situated at an altitude of 7,000 ft., and refers especially to the mine known as the American Nettie, situated in what is known as the American Gold Belt, and the mining methods required on account of its peculiar character.—*Mines and Minerals*, Jan. 1901, pp. 241-45. (Ill.)

Mining.—*Peculiar Mines and Ore Deposits.* Description of a number of peculiar mines and ore deposits in Colorado, among them the mines of Gilpin and Clear Creek Counties, which are on regular fissure veins in granitic formations; those of Leadville, which are "blanket-contact veins" between porphyry and limestone; those of Cripple Creek being fissure veins in eruptive rocks; those of San Juan and the La Plata Mountains, fissure veins in eruptive rock. In each of these regions there are to be found anomalous and peculiar deposits, which the author describes.—*Mines and Minerals*, Dec. 1900, pp. 224, 225. (Ill.)

—— *The Future of Mining.* By Dr. Nelson P. Hulst. This is an extract from an address by the author, delivered to the graduating class of the Michigan College of Mines, in which he deals with the opportunities which the present offers and the future promises to mining students.—*Mines and Minerals*, Jan. 1901, pp. 246-48.

Mining Methods.—*Notes on Hydraulic Mining.* By George H. Evans, C.E.M.E. The author discusses the more important points that must be considered by the superintendent of hydraulic mining operations, such as water facilities, the nature of the ground through which the ditches, flumes and pipe-line have to be constructed, capacity of the various pipes, friction in small pipes, choice of motors, strength of material, chains, hemp, manilla, wire ropes, methods of treating alluvial deposits, nature of country for grades, etc.—*Mines and Minerals*, Dec. 1900, pp. 202, 203. (Ill.)

REVIEWS.

Technische Mechanik, Ein Lehrbuch der Statik und Dynamik für Maschinen- und Bauingenieure. Technical Mechanics, A Treatise on Statics and Dynamics for Mechanical and Civil Engineers. By E. Autenrieth, Chief Building Instructor and Professor at the Royal Technical High School at Stuttgart. Julius Springer, Berlin. xxii and 558 pages. Price 12 marks; 1900.

This volume is founded upon the course of lectures given by the author to the students of the high school, and represents the outcome of many years of experience in the training of young engineers. He has a very strong opinion, in which we are fully in accord with him, that the standpoint of the technical school in the treatment of the study of mechanics, which is so essential to the engineer, should differ considerably from the academical standpoint of the University.

Students of the technical high schools in Germany, like those of our own technical colleges, are in general endeavouring to attain, in as short a time as possible, a position in which they may at the same time become self-supporting and have opened up to them the avenues leading to the high places of their profession, should they prove to possess the ability and energy needed, in order to follow them.

Such students have not the time to take up an extended study of dynamics as an abstract science, even in Germany, where boys do, as a rule, learn something more at school than merely how to behave as gentlemen, and to hold their own among their fellows.

Both on account of its primary importance to the engineer and owing to its being the simpler method of approach to the subject from a practical point of view, the author prefers to begin with the subject of statics, and to begin with the consideration of force as directly known by the senses as a push or a pull. A typical example of his terse and practical methods is to be found in his definition of the direction of a force as that taken by a string, fixed at one end, and subjected to a pull by the force in question.

We are glad to note that this method of treatment does not lead him to introduce the theorem known as the parallelogram of forces, by means of the unsatisfactory so-called statical proofs which prevailed so generally until Thomson and Tait, in their well-known treatise, recalled the attention of mathematicians and physicists to the simple and direct methods of Newton, which had so long been neglected by the writers of text-books.

The author introduces this theorem as an axiom in the first place, and later on, after the consideration of velocity and acceleration, the idea of mass is introduced by the aid of concrete examples of inertia. The equality of mass acceleration and force is then established, from which it follows that forces are to be compounded in the same manner as velocities and accelerations, affording the requisite proof of the previously assumed axiom.

With respect to the practical instruction of engineering students, as the result of our own experience in following a very similar line, we would suggest as an improvement the supplementing of the provisionally axiomatic introduction of the parallelogram of forces by experimental illustrations, which are very easily given, and which, moreover, amount to a demonstration of the approximate truth of the theory within the limit of errors of observation. The method of treatment adopted enables the author to cover all the ground requisite for most engineers in the field of the mechanics of solid bodies, including a consideration of the problems of the flexure of beams and of torsional vibrations, without going into general considerations with regard to theories of elasticity in solids, and without making any formidable demands upon the mathematical acquirements of his readers. A student who can solve a few of the simplest differential equations—and such knowledge every engineering student should acquire—will find absolutely no mathematical difficulties in his way; and with the exception of half-a-dozen paragraphs, the whole book may be followed by any one having no higher mathematical knowledge than a familiarity with the veriest elements of co-ordinate geometry and the notation of the calculus. The old Cambridge method of treating mechanics, which is gradually and with much difficulty being extirpated, was to carry the study to a considerable degree of development without the use of the notation and ideas which Newton and Leibnitz had introduced as most appropriate for the attack of dynamical problems. The result has been that many students, having been made to follow the most elaborate and roundabout methods of arriving at results attainable by the simplest means, and believing that differentiation and integration were things far more awful, have acquired a horror of their very names.

As a matter of fact, the avoidance of these simple operations in the earlier stages of mechanics is very much on a par with the action of a host who should refuse to open his door to his guests until they had first succeeded in getting inside the house through one of the upper storey windows. In Germany they let the students in by the door instead of making them climb in by the windows, as their educational authorities have for a long time past grasped a fact which most of our own schoolmasters have not, that quite sufficient obstacles have been provided by nature to develop the intellectual muscles of the young engineer without the assistance of the schoolmaster in building up artificial ones.

The theory of the equilibrium of structures, with the graphics of link-works and explanations of Culmann's and Ritter's methods, are simply but adequately considered with applications to roof trusses and girders, and in the case of structures in which the stresses are statically indeterminate, owing to the presence of superfluous struts or ties, it is shown how the determination can be made by application of the principle of the conservation of energy. The author himself retains the old expression "virtual velocities."

The work concludes with two well-written and practical chapters, dealing respectively with the problems of rolling friction and with the dynamics of machinery, which latter, while in touch with

the author's individuality, naturally follows more or less the lines originally laid down by Reuleaux. The book is one which we would specially recommend to professors and others who may have to do with the training of engineering students. We often wonder why it is that so few German scientific works contain an alphabetical index. The table of contents is full and complete, but the author would be rendering a service to his readers if he would add an index to the second edition, which we have very little doubt will shortly be called for.

British Locomotives, their History, Construction, and Modern Development. By C. J. Bowen Cooke, Outdoor Assistant, London and North Western Railway Locomotive Department. Crown 8vo, 422 pp., Illus., Third Edition, 7*s.* 6*d.* London: Whittaker & Co., 1900.

Although a considerable amount of attention has been bestowed of late years by the man in the street upon the various creations of the engineer which tend to annihilate time and space, yet there is no doubt that his chief admiration has always been reserved for the locomotive. This is perhaps owing to the fact that locomotives are, as a well-known novelist has happily phrased it, the "livest things made! They glare through their spectacle-plates, they tilt their noses contemptuously in the air, and, when their insides are gone, they adorn themselves with red lead, and leer like decayed beauties." A graphic sentence, though not technically correct.

Mr. Bowen Cooke, whose official position enables him to speak with authority, has presented us with an extremely interesting book, which is intended to form a *via media* between the strictly technical side of locomotive engineering and the non-professional, and consequently often misleading, point of view.

Many of our readers are probably already aware of the admirable manner in which this object has been effected, as the volume is now in its third edition.

The first two chapters are devoted to the early history of the locomotive; the action of steam in the cylinders is then lucidly explained, and various valve gears described and illustrated. Subsequent chapters deal with boilers, boiler fittings, cylinders, general details, erecting work, and valve setting. These chapters deserve high commendation, and are of much value.

The classification and balancing of engines is then touched upon, following which are two fully-illustrated sections dealing with engines in use on the London and North Western, and other leading railways.

The remaining chapters of this fascinating book are devoted to tenders and brakes, the combustion and consumption of fuel, and the duties of drivers and firemen.

The automatic vacuum and Westinghouse systems are well detailed, though no mention is made of the quick-acting type of the latter brake devised for use on long passenger and goods trains.

As is well-known, the weight of our trains has been continually increasing, and this has, of course, necessitated the use of heavier and more powerful locomotives.

These pages, which form a complete history of the locomotive throughout a century of continuous and magnificent progress, show the admirable manner in which our locomotive engineers have coped with the ever-increasing demand for speed and power.

The London and North Western and the North Eastern compounds are described, but these have been so fully dealt with in recent issues of FEILDEN'S MAGAZINE that further reference is superfluous.

Among the various novelties in detailed construction introduced of late years will be found Belpaire fire-boxes, water tube fire-boxes, the liquid fuel system, steam sanding and reversing gears, sight-feed lubricators, and other accessories, which tend to increase the efficiency of the locomotive, and the comfort of drivers and firemen.

The use of engines with four and six coupled wheels and outside cylinders for express passenger trains is a noteworthy departure; a few years since it appeared likely that outside cylindered engines would, with one or two exceptions, become as extinct as the dodo in this country for both passenger and goods work.

A glance at the dimensions of some of the most recent locomotives, viz., boilers with a heating surface of 2,000 sq. ft., cylinders of 20 ins. diameter and 26 ins. stroke, and weights of from 15 to over 19 tons on driving wheels, shows that the limits of the loading gauge have been practically reached on several lines, so that interesting developments may be expected in the new century.

It is, however, doubtful if the seating capacity of our trains can be increased to any extent; considerable delay is often caused at present owing to their already abnormal length.

Mr. Bowen Cooke has given us a book of more than ordinary merit.

Well up to date, copiously illustrated, written in clear and terse language, it should be in the possession of all admirers of that most beautiful mechanical creation of the age, the locomotive.

Those interested in enginemen are referred to "Engine Driving Life," by Michael Reynolds, himself a driver, whose books have been a source of knowledge and pleasure to numerous readers, and who probably first created the demand for that class of literature of which the work under review is so excellent an example.

THE ATTENTION OF EMPLOYERS in our great industrial-engineering establishments is specially directed to the announcement under the heading "Workshop Practice." Those British manufacturers among our numerous subscribers who will assist us in popularising this section will be rendering themselves real service.